DOE/OR/21548-436
CONTRACT NO. DE-AC05-86OR21548

WELDON SPRING SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1993

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

MAY 1994 REV. 0

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

Printed in the United States of America. Available from the National Technical Information Service, NTIS, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161

NTIS Price Codes - Printed copy: A22
Microfiche: A01

DOE/OR/21548-436

Weldon Spring Site Remedial Action Project

Weldon Spring Site Environmental Report for Calendar Year 1993

Revision 0

May 1994

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63304

for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

m:\users\joanne\aser93\master.doc

40 CFR 61 - Subpart H - The National Emission Standards for Emissions of Radionuclides Other than Radon From Department of Energy Facilities

61.94 Compliance and Reporting

An annual report is required and the SER is fulfilling the requirement.

Each report shall be signed and dated by a corporate officer or public official in charge of the facility and contain the following declaration immediately above the signature line: "I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See, 18 U.S.C. 101."

S.H. McCracken 5/25/94

Steve McCracken

051394

MK-FERGUSON A MORRISON KNUDSEN COMPANY Weldon Spring Site Remedial Action Project Contract No. DE-AC05-86OR21548	 Rev. No. 0
PLAN TITLE: Weldon Spring Site Environmental Report for Calendar Year 1993	

APPROVALS

Melvin H. Lutz — 5.17.94
Originator — Date

[signature] — 5/17/94
Department Manager — Date

Gregory Dwyer for P. Cate — 5/17/94
Quality Assurance Manager — Date

[signature] — 5/18/94
Project Director (or Deputy Project Director) — Date

m:\users\joanne\aser93\aser.apr

DOE/OR/21548-436

Weldon Spring Site Remedial Action Project

EXECUTIVE SUMMARY

Environmental Report for Calendar Year 1993

Revision 0

May 1994

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63304

for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548

m:\users\joanne\aser93\execsum

EXECUTIVE SUMMARY

This *Weldon Spring Site Environmental Report for Calendar Year 1993* has been prepared to provide information about the public safety and environmental protection programs conducted by the Weldon Spring Site Remedial Action Project (WSSRAP). The Weldon Spring site is located in southern St. Charles County, Missouri, approximately 48 km (30 mi) west of St. Louis. The site consists of two main areas, the Weldon Spring Chemical Plant and raffinate pits and the Weldon Spring Quarry. The chemical plant, raffinate pits, and quarry are located on Missouri State Route 94, southwest of U.S. Route 40/61.

The objectives of the *Site Environmental Report* are to present a summary of data from the environmental monitoring program, to characterize trends and environmental conditions at the site, and to confirm compliance with environmental and health protection standards and requirements. The report also presents the status of remedial activities and the results of monitoring these activities to assess their impacts on the public and environment.

This report includes monitoring data from routine radiological and nonradiological sampling activities. These data include estimates of dose to the public from the Weldon Spring site; estimates of effluent releases; and trends in groundwater contaminant levels. Also, applicable compliance requirements, quality assurance programs, and special studies conducted in 1993 to support environmental protection programs are reviewed.

There were no unplanned releases from the site in 1993. Dose estimates presented in this report are based on hypothetical exposure scenarios of public use of areas near the site. In addition, release estimates have been calculated on the basis of 1993 National Pollutant Discharge Elimination System (NPDES) and air monitoring data. Effluent discharges from the site under routine NPDES and National Emission Standards for Hazardous Air Pollutants (NESHAPs) monitoring were below permitted levels for total suspended solids and biochemical oxygen demand except on four occasions.

MONITORING OVERVIEW

WSSRAP environmental management programs are designed to ensure that releases from the site are at levels demonstrably and consistently "as low as reasonably achievable" (ALARA). The ALARA principle drives the work activities related to site remediation and contaminant cleanup programs under U.S. Environmental Protection Agency (EPA) enforcement of the *Comprehensive Environmental Response Compensation and Liability Act* (CERCLA).

The ALARA principle is applied through effluent and environmental monitoring programs that provide early detection of contaminants and provide data required to assess potential impacts to the environment. Routine monitoring also ensures compliance with applicable State and Federal permits and regulations.

REGULATORY COMPLIANCE

The Weldon Spring site is listed on the National Priorities List (NPL) and is governed by the CERCLA. Under the CERCLA, the WSSRAP is subject to meeting or exceeding applicable or relevant and appropriate requirements of Federal, State, and local laws. Primary regulations include the *Resource Conservation Recovery Act* (RCRA), *Clean Water Act* (CWA), *Clean Air Act* (CAA), *Toxic Substances Control Act* (TSCA), and, because the U.S. Department of Energy (DOE) is the lead agency for the site, the requirements of the *National Environmental Policy Act* (NEPA).

A major accomplishment under the CERCLA in 1993 was the presentation of the *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (ROD) (Ref. 10). This document was signed by EPA and DOE in September 1993.

The ROD is based on the *Proposed Plan for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 55) and the *Remedial Investigation/Feasibility Study-Final Environmental Impact Statement*, and public comment received from these documents. This decision document presents the selected remedial action for the chemical plant area of the Weldon Spring site. The remedial action uses chemical stabilization/solidification as treatment to address the various sources of contamination at the chemical plant including soils, sludge, sediment and material placed in short-term storage as a result of previous response actions. After treatment, the materials will be placed in an on-site engineered disposal cell.

Other notable compliance activities included treatment and discharge of water from the quarry and site water treatment plants, completion of the temporary storage area, placement of quarry bulk wastes at the temporary storage area, initiation of an archeological review for the soils borrow area, and obtaining a nationwide permit for wetland elimination.

MONITORING SUMMARY

Environmental monitoring data showed that total emissions of radiological contaminants from the Weldon Spring site were low in 1993. Airborne particulate monitoring indicated no distinguishable difference in effluent releases from the Weldon Spring site as compared to background levels. The 1993 release estimate was 12.7 Ci.

Release estimates for water increased slightly from the 1992 release estimate of 0.15 Ci to 0.177 Ci in 1993. These effluent releases continued to be below compliance levels. Data from groundwater and surface water monitoring indicated no measurable impact on drinking water sources from Weldon Spring site contaminants.

Dose Estimates

In 1993, the maximum committed dose to a hypothetical individual at the boundary of the chemical plant site was 0.03 mrem (0.0003 mSv). The maximum committed dose to a hypothetical individual at the boundary of the quarry was 1.9 mrem (0.019 mSv). These scenarios assumed an individual walking along the perimeter of the site—once a day at the chemical plant/raffinate pits and twice a day at the quarry—250 days per year. This hypothetical individual also consumes fish, sediment, and water from lakes and other bodies of water in the area.

The collective dose, based on an affected population of 112,000, was 0.12 person-rem (0.0012 person-Sv). This calculation is based on recreational use of the Busch Conservation Area and the Missouri Department of Conservation recreational trail (the Katy Trail) near the quarry. These estimates are below the DOE guideline of 100 mrem (1 mSv) annual committed effective dose equivalent for all exposure pathways. Section 4 and Appendix B of this report provide additional information on the dose assumptions and calculations.

Air Monitoring

No airborne radionuclide releases other than low volume airborne radioactive particulate occurred at the site perimeter or at off-site monitoring locations in 1993. Statistical analysis of air particulate data indicates that the concentrations at the three site perimeter locations and one off site location were greater than those recorded at the background locations. The average radon concentration at the quarry perimeter was 0.25 pCi/l above background and the estimated Rn-222 release was 12.5 Ci (4.6 x 10^{11} Bq). Among the monitoring stations that failed the statistical analysis, only one station showed 1993 annual concentrations greater than the comparative 1991 and 1992 annual concentrations.

The results of NESHAPs monitoring indicated that all doses to the public at critical receptor locations were less than 1.0 mrem per year. This dose is below the NESHAPs standard of 10 mrem per year. Critical receptor locations upon which this dose was estimated included the Missouri Highway Maintenance Facility, Francis Howell High School, and the Department of the Army Weldon Spring Training Area.

During periods of asbestos abatement work, airborne asbestos was monitored as a part of the nonradiological air monitoring program. Only 10 of the 277 samples indicated results above the detection limits. Samples above the detection limits ranged from 0.0006 fibers per milliliter of air (f/ml) to 0.0022 f/ml. These concentrations were within the range of normal background fiber concentrations and indicated that containment was effective.

<u>NPDES Monitoring</u>

Intermittent surface runoff at the Weldon Spring Chemical Plant transported uranium from the site in 1993 through seven major discharge routes as identified in Section 6 of this report. Radionuclide release estimates were calculated on the basis of the activity of uranium. The estimate of uranium released to water was 0.087 Ci for U-234, 0.004 Ci for U-235, and 0.086 Ci for U-238.

Annual average uranium concentrations increased at abandoned process sewer outfall (NP-0001) and at Ash Pond outfall (NP-0003) due to above normal precipitation for 1993 and/or increased work activity in these drainages. The annual average in the southeast area of the site (NP-0005) decreased to the lowest level since before 1987. This reduction is attributed to removal of contaminated soil during construction of the site water treatment plant in 1991 and continued effective erosion control measures.

The Missouri River was monitored during 1993 in support of quarry and site water treatment plant operations. Both the site and quarry water treatment plants operated near full capacity for the majority of 1993. Surface water and sediment samples were taken from the river and analyzed for uranium. The river receives discharges from the water treatment plants.

Surface Water

Surface water monitoring in 1993 indicated that the distributions and concentrations of contaminants remained similar to historic levels with one exception. One of the first bimonthly samples from the Femme Osage Slough showed uranium concentrations noticeably higher than historic uranium concentrations. This was determined to be caused by flood conditions. The furthest monitoring locations downstream from the chemical plant (SW-2001 and SW-2016) remained within background levels; however, uranium concentrations were above background at Busch Lakes 34, 35, and 36 and at the Femme Osage Slough.

Groundwater

The groundwater monitoring program included extensive monitoring for radiological and nonradiological compounds. Radiological results for the St. Charles County well field remained within background levels. No detectable concentrations of the six nitroaromatic compounds of concern were found in groundwater monitoring wells south of the Femme Osage Slough, which is near the quarry.

Flooding of the St. Charles County Well Field by the Missouri River inundated 26 groundwater monitoring locations; therefore some wells were not sampled during the third and fourth quarters of 1993. Later sampling indicated that the St. Charles County production wells were not impacted by contaminants migrating from the bulk wastes in the quarry during the flooding.

Environmental monitoring indicates that the largest amount of contamination is still present in the bedrock of the quarry rim and the alluvial materials and bedrock north of the Femme Osage Slough. Total uranium concentrations remain within background levels, and no detectable concentrations of nitroaromatic compound were identified south of the slough or in any of the St. Charles County production wells.

At the chemical plant, uranium, sulfate, nitrate, and nitroaromatic compounds in groundwater and springs remained near historic ranges. High concentrations of uranium typically occur in groundwater wells near Raffinate Pit 4 and at the southeast corner of the chemical plant. Contaminant transport continued to be confined to the upper weathered zone of the bedrock aquifer at the plant.

Biological

The results of biological monitoring of fish from Busch Lakes 34, 35, and 36 showed uranium concentrations ranging from 0.001 pCi/g to 0.129 pCi/g in edible portions.

Background corn and soybeans samples were collected under the foodstuffs monitoring program. Uranium concentrations were less than 0.05 pCi/l with no significant difference among crop types.

ABSTRACT

This *Site Environmental Report for Calendar Year 1993* describes the environmental monitoring programs at the Weldon Spring Site Remedial Action Project (WSSRAP). The objectives of these programs are to assess actual or potential exposure to contaminant effluents from the project area by providing public use scenarios and dose estimates, to demonstrate compliance with Federal and State permitted levels, and to summarize trends and/or changes in contaminant concentrations from environmental monitoring program.

In 1993, the maximum committed dose to a hypothetical individual at the chemical plant site perimeter was 0.03 mrem (0.0003 mSv). The maximum committed dose to a hypothetical individual at the boundary of the Weldon Spring Quarry was 1.9 mrem (0.019 mSv). These scenarios assume an individual walking along the perimeter of the site—once a day at the chemical plant/raffinate pits and twice a day at the quarry—250 days per year. This hypothetical individual also consumes fish, sediment, and water from lakes and other bodies of water in the area.

The collective dose, based on an effected population of 112,000 was 0.12 person-rem (0.0012 person-Sv). This calculation is based on recreational use of the August A. Busch Memorial Conservation Area and the Missouri Department of Conservation recreational trail (the Katy Trail) near the quarry. These estimates are below the U.S. Department of Energy requirement of 100 mrem (1 mSv) annual committed effective dose equivalent for all exposure pathways. Results from air monitoring for the National Emission Standards for Hazardous Air Pollutants (NESHAPs) program indicated that the estimated dose was 0.38 mrem, which is below the U.S. Environmental Protection Agency (EPA) standard of 10 mrem per year.

Comprehensive monitoring indicated that emissions of radiological compounds in airborne and surface water discharges from the Weldon Spring site were 12.5 Ci (4.6×10^{11} Bq) and 1.771×10^{-1} Ci (6.5×10^{9} Bq), respectively (260 grams and 409 grams, respectively). There was no measurable impact to any drinking water source and no unplanned releases occurred in 1993. Substances of concern in groundwater south of the Femme Osage Slough and the St. Charles County well field continued to remain within background ranges.

Various State and Federal permit levels are monitored under these National Pollutant Discharge Elimination System (NPDES) permits. In 1993, permit levels were maintained except on five occasions. These all occurred at the administration building sewage treatment plant for biochemical oxygen demand (BOD) and total suspended solids (TSS).

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

NUMBER **PAGE**

TABLE OF CONTENTS (Continued)

NUMBER **PAGE**

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

NUMBER PAGE

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (Continued)

1 INTRODUCTION

The Weldon Spring Site Remedial Action Project (WSSRAP) is part of the U.S. Department of Energy (DOE) Environmental Restoration Program, one of the remedial action programs under the direction of the DOE Office of Environmental Restoration and Waste Management. This *Site Environmental Report for Calendar Year 1993* is a summary of the environmental monitoring results obtained in 1993 and the status of Federal and State compliance activities.

DOE requirements for environmental monitoring and protection of the public, as well as the mandate for this document, are designated in DOE Order 5400.1, *General Environmental Protection Program,* DOE Order 5400.5, *Radiation Protection,* and its implementing guide, DOE/EH-0173T: *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (Ref. 32).

In 1993, environmental monitoring activities were conducted to support remedial action under the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA), the *Clean Air Act* (CAA), the *National Environmental Policy Act* (NEPA), the *Clean Water Act* (CWA), and other applicable regulatory requirements. The monitoring program at the WSSRAP has been designed to ensure protection of public safety and to evaluate the effects on the environment, if any, from remediation activities.

The purposes of the *Site Environmental Report for Calendar Year 1993* include providing general information on the WSSRAP and the current status of remedial activities; presenting summary data and interpretations for the 1993 Environmental Monitoring Program; providing information on mitigative actions for remedial action; documenting continuing compliance with Federal, State, and local requirements; providing dose estimates for radiological and chemical compounds as appropriate for the WSSRAP; and summarizing trends and/or changes in contaminant concentrations to support remedial actions, ensure public safety, and maintain surveillance monitoring requirements.

1.1 Site Description

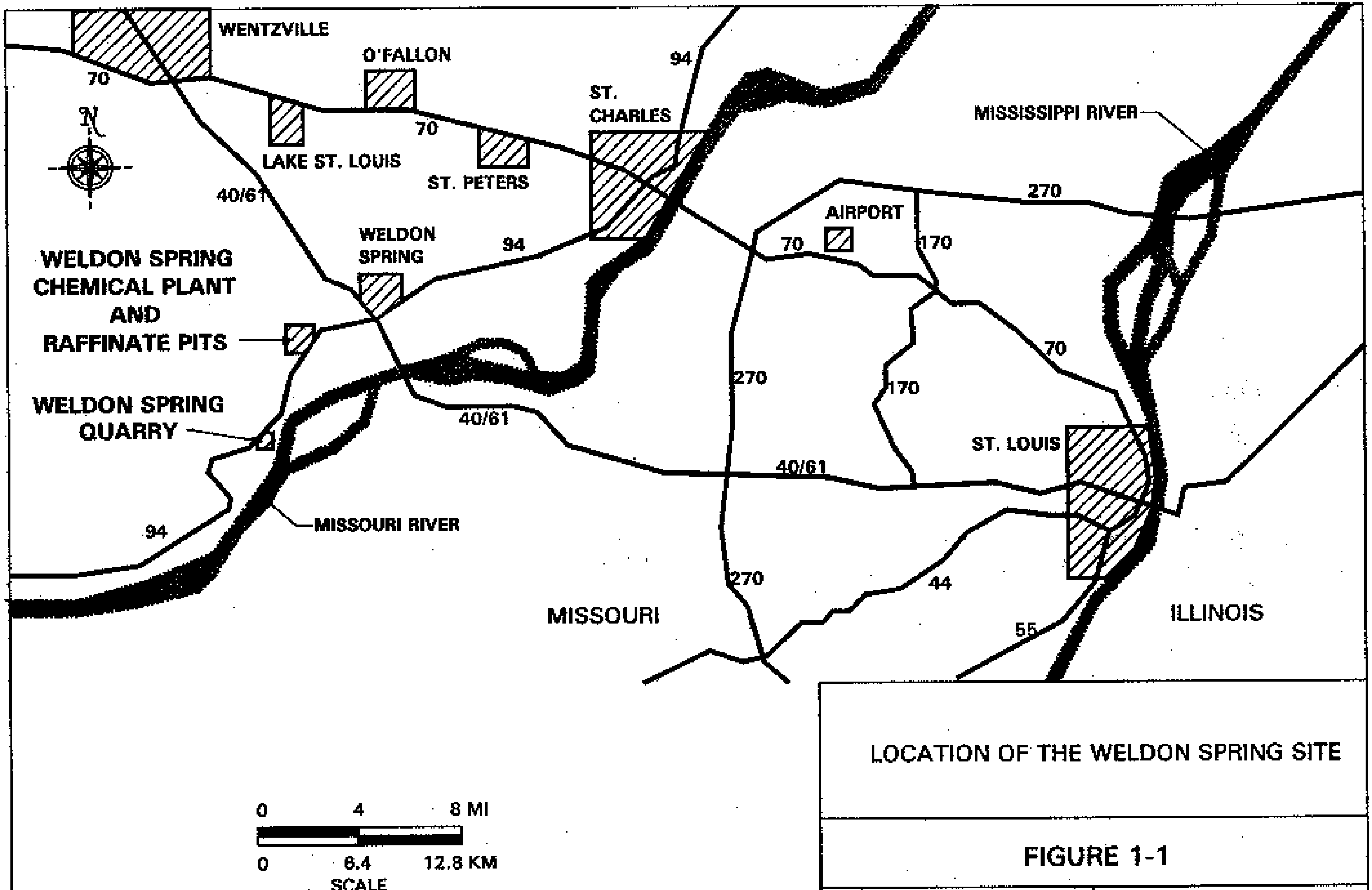
The Weldon Spring site is located in southern St. Charles County, Missouri approximately 48 km (30 mi) west of St. Louis (Figure 1-1). The site consists of two main areas, the Weldon Spring Chemical Plant and raffinate pits and the Weldon Spring Quarry, both located along Missouri State Route 94. Access to both the site and quarry is restricted by locked chain link fences with 24 hour on-site security.

The Weldon Spring Chemical Plant is a 67.2 ha (166 acres) area which operated as the Weldon Spring Uranium Feed Materials Plant (WSUFMP) until 1966. Buildings are contaminated with asbestos, hazardous chemical substances, and small quantities of uranium and thorium. Radiological and chemical (polychlorinated biphenyls, nitroaromatic compounds, metals and inorganic ions) contaminants can also be found in the soil in several areas around the site. The raffinate pits are located on the chemical plant site and include four settling basins that cover approximately 10.5 ha (26 acres) (Figure 1-2). These pits are radiologically contaminated with uranium and thorium residues and chemical contaminants including nitrate, flouride, polychlorinated biphenyls (PCBs) and various heavy metals.

The Weldon Spring Quarry is a former 3.6 ha (9 acres) limestone quarry located south-southwest of the chemical plant area (Figure 1-3). The quarry is essentially a closed basin; surface water within the rim flows to the quarry floor and into a pond. The amount of water in the pond varies seasonally, but the pond is never dry. The quarry contains radiological and chemical contaminants including uranium, thorium, metals, nitrates, PCBs, semivolatiles, nitroaromatics, and asbestos.

1.2 Site History

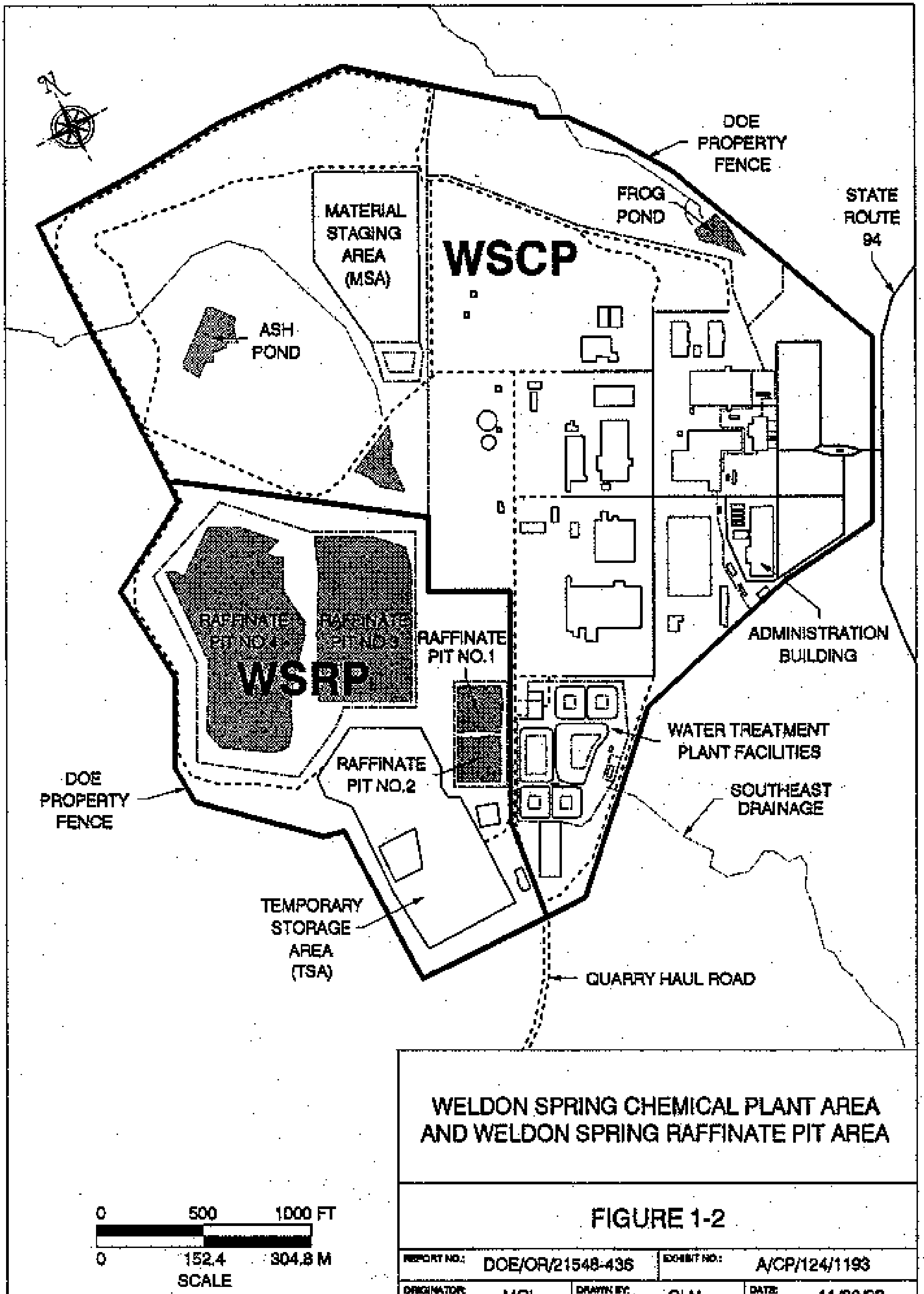
From 1941 to 1945, the U.S. Department of the Army produced trinitrotoluene (TNT) and dinitrotoluene (DNT) at the Weldon Spring Ordnance Works, which covered 6,974 ha (17,232 acres) of land that now includes the Weldon Spring site. By 1949, all but about 809 ha (2,000 acres) had been transferred to the State of Missouri (August A. Busch Memorial Conservation Area) and to the University of Missouri (agricultural land). Except for several small parcels transferred to St. Charles County, the remaining property became the Army training area.



LOCATION OF THE WELDON SPRING SITE

FIGURE 1-1

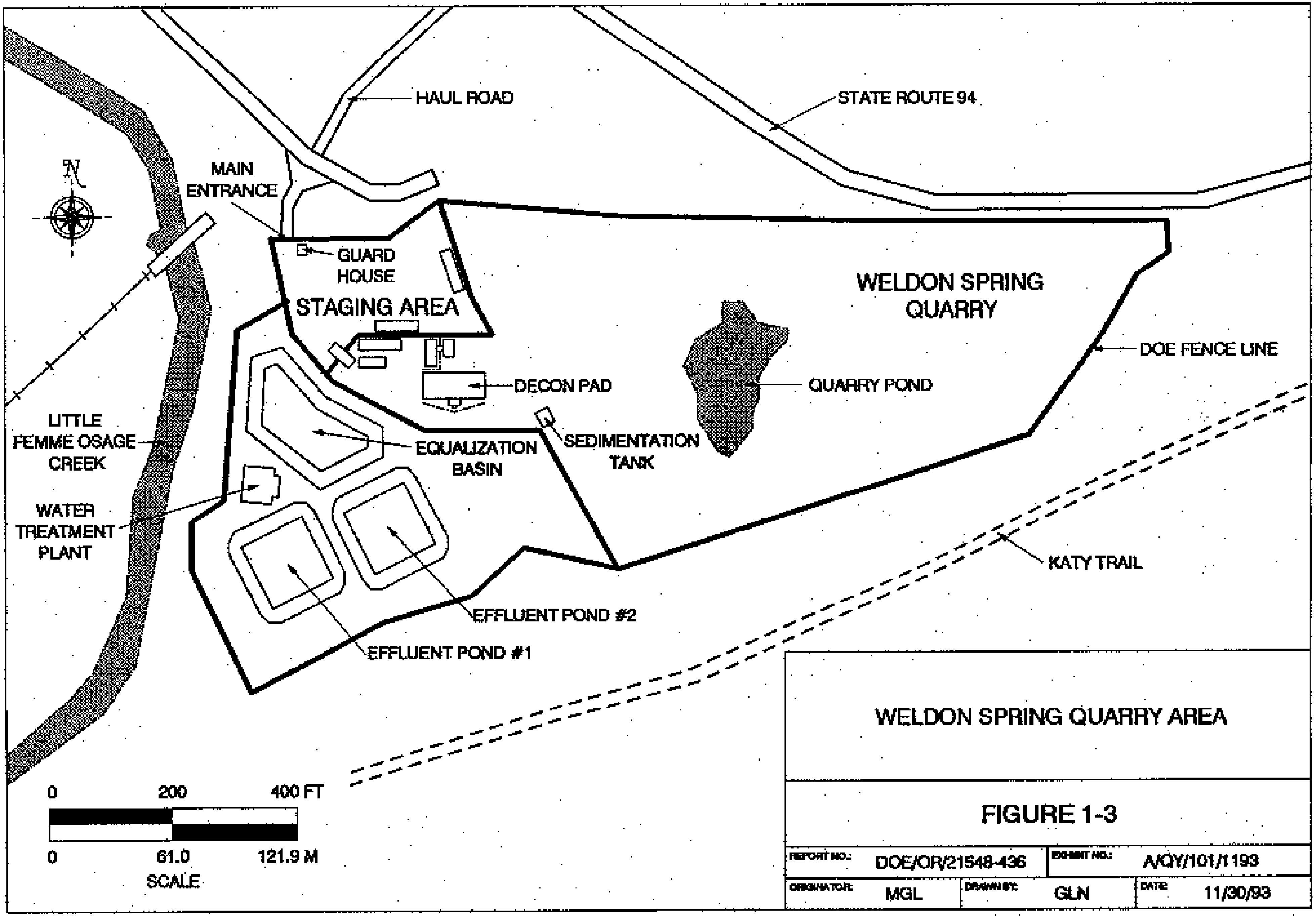
REPORT NO.:	DOE/OR/21548-436	EXHIBIT NO.:	A/VP/077/1193		
ORIGINATOR:	MGL	DRAWN BY:	GLN	DATE:	3/11/94



WELDON SPRING CHEMICAL PLANT AREA
AND WELDON SPRING RAFFINATE PIT AREA

FIGURE 1-2

REPORT NO.:	DOE/OR/21548-436	EXHIBIT NO.:	A/CP/124/1193		
ORIGINATOR:	MGL	DRAWN BY:	GLN	DATE:	11/30/93



WELDON SPRING QUARRY AREA

FIGURE 1-3

REPORT NO.:	DOE/OR/21548-436		EXHIBIT NO.:	A/QY/101/1193	
ORIGINATOR:	MGL	DRAWN BY:	GLN	DATE:	11/30/93

Through a Memorandum of Understanding between the Secretary of the Army and the General Manager of the Atomic Energy Commission (AEC), 83 ha (205 acres) of the former ordnance works property was transferred in May 1955 to the AEC for construction of the WSUFMP, now referred to as the Weldon Spring Chemical Plant. Considerable explosives decontamination was performed by the Atlas Powder Company and the Army prior to WSUFMP construction. From 1958 until 1966, the WSUFMP converted processed uranium ore concentrates to pure uranium trioxide, intermediate compounds, and uranium metal. A small amount of thorium was also processed. Wastes generated during these operations were stored in the four raffinate pits.

In 1958, the AEC acquired title to the Weldon Spring Quarry from the Army. The Army had used it since 1942 for burning wastes from the manufacture of TNT and DNT and disposal of TNT-contaminated rubble during the operation of the ordnance works. Prior to 1942, the quarry was mined for limestone aggregate used in the construction of the ordnance works. The AEC used the quarry from 1963 to 1969 as a disposal area for uranium residues and a small amount of thorium residue. Material disposed of in the quarry during this time consisted of building rubble and soils from the demolition of a uranium ore processing facility in Saint Louis. These materials were contaminated with uranium and radium. Other radioactive materials in the quarry include drummed wastes, uncontained wastes, and contaminated process equipment.

The WSUFMP was shut down in 1966, and in 1967 the AEC returned the facility to the Army for use as a defoliant production plant to be known as the Weldon Spring Chemical Plant. The Army started removing equipment and decontaminating several buildings in 1968. However, the defoliant project was canceled in 1969 before any process equipment was installed. The Army retained responsibility for the land and facilities of the chemical plant, but the 20.6 ha (51 acre) tract encompassing the Weldon Spring raffinate pits was transferred back to the AEC.

The Weldon Spring site was placed in caretaker status from 1981 through 1985, when custody was transferred from the Army to the Department of Energy. In 1985, the DOE proposed designating control and decontamination of the chemical plant, raffinate pits, and quarry as a major project. A Project Management Contractor (PMC) for the Weldon Spring Site Remedial Action Project was selected in February 1986. In July 1986, a DOE project office was established on site, and the PMC, MK-Ferguson and Jacobs Engineering Group, Inc., assumed control of the site on October 1, 1986. The quarry was placed on the Environmental Protection Agency's National Priorities List (NPL) in July 1987. The DOE redesignated the site as a Major Acquisition System in May 1988. The chemical plant and raffinate pits were added to the NPL in March 1989.

A more detailed presentation of the production, ownership, and waste history of the Weldon Spring site is available in the *Remedial Investigation for Quarry Bulk Wastes* (Ref. 1) and the *Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site* (Ref. 2).

1.3 Geology and Hydrogeology

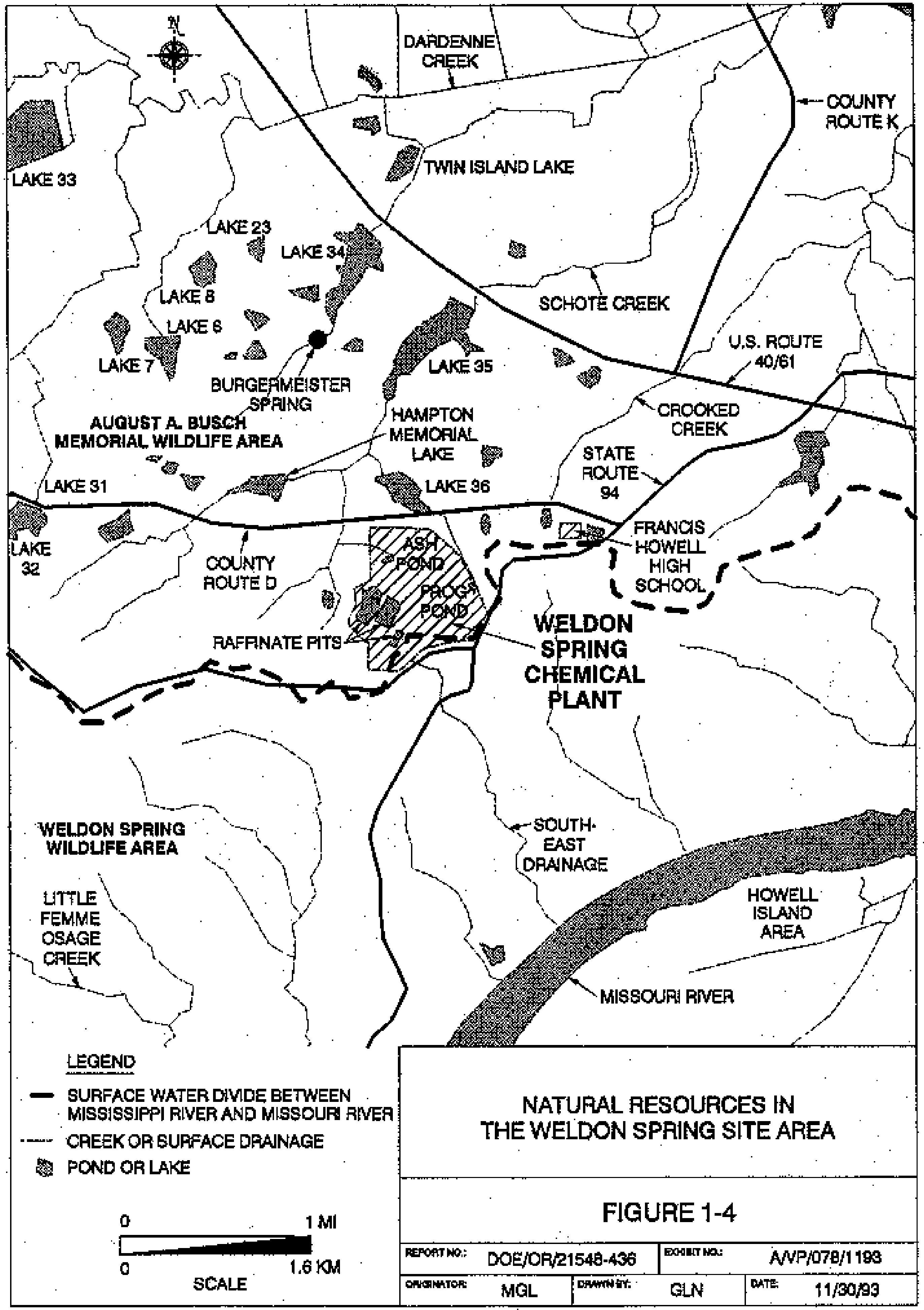
The Weldon Spring site is situated near the boundary between the Central Lowland and the Ozark Plateau physiographic provinces. This boundary nearly coincides with the southern edge of Pleistocene glaciation that covered the northern half of Missouri over 10,000 years ago (Ref. 3).

The Weldon Spring quarry is located in low limestone hills near the western bank of the Missouri River. The mid-Ordovician bedrock of the quarry area is predominantly limestone and dolomite. Near the quarry, the carbonate rocks dip to the northeast at a gradient of 11 m/km to 15 m/km (58 ft/mi to 79 ft/mi) (Ref. 3).

There are three bedrock aquifers underlying St. Charles County. The shallow aquifer consists of Mississippian limestones and the middle aquifer consists of the Kimmswick Limestone. The deep aquifer consists of formations from the top of the St. Peter Sandstone to the base of the Potosi Dolomite. Alluvial aquifers are present near the Missouri and Mississippi rivers.

1.4 Surface Water System and Use

The chemical plant/raffinate pits area is located on the Missouri-Mississippi River surface drainage divide (Figure 1-4). There are six surface water bodies at the chemical plant area: four raffinate pits, Ash Pond, and Frog Pond. Elevations on the site range from approximately 185.4 m (608 ft) above mean sea level (msl) near the northern edge of the site to 205 m (672 ft) above msl near the southern edge. The topography of the site is gently undulating in the upland areas, typical of the Central Lowlands physiographic province. South of the site, the topography changes to the narrow ridges and valleys and short, steep streams common to the Ozark Plateau physiographic province (Ref. 3).



NATURAL RESOURCES IN THE WELDON SPRING SITE AREA

FIGURE 1-4

No natural drainage channels traverse the site, although remnants of a channel through the Ash Pond area are present. Drainage from the southeastern portion of the site generally flows southward in a tributary referred to as the Southeast Drainage (5300 Drainageway), that flows to the Missouri River.

In the surrounding areas, man-made lakes in the August A. Busch Memorial Conservation Area are used for public fishing and boating. No swimming is allowed in the conservation area, although some may occur. No surface water is used for irrigation or as a public drinking water supply. The northern and western portions of the site, including Frog Pond and Ash Pond areas, drain to tributaries for Busch Lakes and Schote Creek, which in turn enter Dardenne Creek, which ultimately drains to the Mississippi River. These drainages, Burgermeister Spring, and Lakes 34, 35, and 36 are contaminated as a result of previous plant operations.

The Weldon Spring Quarry is situated on a bluff of the Missouri River valley about 1.6 km (1 mi) northwest of the Missouri River at approximately river Mile 49. No direct surface water runoff enters or exits the quarry due to the topography of the area. A 0.2 ha (0.5 acre) pond within the quarry proper acts as a sump which accumulates both direct rainfall within the quarry and the groundwater. Recent dewatering activities in the quarry suggest that the sump interacts directly and rapidly with the local groundwater. The sump is contaminated with radiological and chemical compounds. The quarry pond is not used for any operational or public water supply and is maintained by the DOE within an access controlled and restricted area.

The Femme Osage Slough, located approximately 213 m (700 ft) south of the quarry is a 2.4 km (1.4 mi) section of the original Femme Osage Creek and Little Femme Osage Creek. The University of Missouri dammed portions of the creeks between 1960 and 1963 during construction of a levee system around the University's experimental farms (Ref. 6). The slough receives contaminated groundwater migrating from the quarry, causing increased uranium concentrations in the slough. The slough is used for recreational fishing.

1.5 Ecology

The Weldon Spring site is surrounded primarily by State Conservation Areas which include the 2,828 ha (6,987 acres) Busch Conservation Area to the north, the 2,977 ha

(7,356 acres) Weldon Spring Conservation Area to the east and south, and the Howell Island Conservation Area, an island in the Missouri River which covers 1,031 ha (2,547 acres) (Figure 1-4). The wildlife areas are managed for multiple uses, including timber, fish and wildlife habitat, and recreation. Fishing comprises a relatively large portion of the recreational use. Seventeen percent of the area is open fields which are leased to sharecroppers for agricultural production. In these areas, a percentage of the crop is left for wildlife use. The main agricultural products are corn, soybeans, milo, winter wheat, and legumes (Ref. 5). The district staff for these wildlife areas consists of 25 full-time employees supplemented by two to 10 workers during the summer months (Appendix C). The Busch and Weldon Spring conservation areas are open year-round, and the number of annual visits to both areas totals about 1,200,000 (Appendix C).

Much of the chemical plant area consists of maintained grasslands and old fields (65.5 ha [162 acres]) that are periodically mowed. Grasses and forbs are found in this habitat including big bluestem, timothy, red tip grass, foxtail, fescue, thistle, and goldenrod. The northwest portion of the chemical plant area (22 ha [55 acres]) is relatively natural and contains forest habitat typically found in the upland areas of eastern Missouri.

The quarry is surrounded by the Weldon Spring Conservation Area and consists primarily of forest with some old field habitat. Much of the quarry floor is old-field habitat and contains a variety of grasses, herbs, and shrubs. The rim and upper portions of the quarry consist primarily of slope and upland forest including cottonwood, sycamore, and oak (Ref. 6).

1.6 Climate

The climate in the Weldon Spring area is continental with warm to hot summers and moderately cold winters. Alternating warm/cold, wet/dry air masses converging and passing through the area cause frequent changes in the weather. Although winters are generally cold and summers hot, prolonged periods of very cold or very warm to hot weather are unusual. Occasional mild periods with temperatures above freezing occur almost every winter and cool weather interrupts periods of heat and humidity in the summer (Ref. 7).

The average annual temperature is 12.8° C (55.1° F). The average daily maximum and minimum temperatures are 19° C (66.2° F) and 6.5° C (43.8° F), respectively. On the average, there are 49 days a year when maximum temperatures are above 32.2° C (90° F).

Minimum daily temperatures below 0° C (32° F) occur about 111 days of the year. Temperatures below -18° C (0° F) are infrequent, only about five days per year. Mean annual precipitation in the area is approximately 92.7 cm (36.5 in.).

Wind data recorded at St. Louis for the period 1941 to 1970 indicate that prevailing winds are from the south during summer and fall, and from the northwest and west-northwest during winter and early spring. The average annual wind speed is about 15.3 kph (9.5 mph) from the south.

A meteorological station is located at the chemical plant to provide data to support the environmental monitoring programs. Data from this station are used to assess meteorological conditions and air transport and diffusion characteristics which help determine possible impacts of airborne releases. In addition, precipitation data are used to correlate water level fluctuations and contaminant concentrations in surface water and groundwater wells.

The meteorological station provides data on wind speed, wind direction, ambient air temperature, barometric pressure, and precipitation accumulation. The results of meteorological monitoring in 1993 are provided in Table 1-1.

TABLE 1-1 Monthly Meteorological Monitoring Results for 1993

Month	Total Precip (in.)	Average Temp (degrees C)	Average Barometric Pressure (millibars)	Average Wind Speed (m/sec)	Predominant Wind Direction
January	3.97	-0.6	993	3.01	NE
February	2.11	-1.1	995	2.96	NW
March	2.79	4.4	989	3.24	NW
April*	3.75	11.7	984	3.25	S
May	2.90	17.8	982	2.81	SE
June	7.05	22.2	983	2.53	S
July	4.77	26.1	962	2.48	S
August*	1.23	21.7	857	1.84	NW
September*	6.03	-	-	2.96	-
October*	3.18	-	-	2.57	-

TABLE 1-1 Monthly Meteorological Monitoring Results for 1993 (Continued)

Month	Total Precip (in.)	Average Temp (degrees C)	Average Barometric Pressure (millibars)	Average Wind Speed (m/sec)	Predominant Wind Direction
November*	4.69	-	-	3.28	-
December*	0.18	-	-	3.49	-

* Data not available for all days
\- No data available

1.7 Land Use and Demography

The population of St. Charles County in 1990 was 212,907; 20% of the population lives in the city of St. Charles, approximately 22.4 km (14 mi) northeast of the Weldon Spring site. The population in St. Charles increased by 48% from 1980 to 1990. The two communities closest to the site are Weldon Spring and Weldon Spring Heights, about 3.2 km (2 mi) to the northeast. The combined population of these two communities in 1990 was 1,131 (see Appendix C). No private residences exist between Weldon Spring Heights and the site. Urban areas occupy about 6% of county land, and nonurban areas occupy 90%; the remaining 4% is dedicated to transportation and water uses.

Francis Howell High School and the Missouri Highway and Transportation Department are both within 1 km (0.6 mi) of the site. Francis Howell High School is about 1 km (0.6 mi) northeast of the site along Missouri State Route 94. The school employs approximately 179 faculty and staff, and about 1,926 students attend school there (Appendix C). Students and staff generally spend about 7 hours to 8 hours per day at the school. The buildings are also used for other activities, such as athletic events and school meetings. The Missouri Highway and Transportation Department, located adjacent to the north side of the chemical plant, employs nine full-time employees (Appendix C). About 300 ha (740 acres) of land east and southeast of the high school is owned by the University of Missouri. The northern third of this land is being developed into a high-technology research park.

2 ENVIRONMENTAL PROTECTION/RESTORATION PROGRAM OVERVIEW

2.1 Project Purpose

The U.S. Department of Energy (DOE) is responsible for the remedial action activities at the Weldon Spring site. The program is known as the Weldon Spring Site Remedial Action Project (WSSRAP). The major goals of the WSSRAP are to eliminate potential hazards to the public and the environment posed by the buildings and waste materials on the Weldon Spring site and, to the extent possible, make surplus real property available for other uses.

Remedial actions are subject to U.S. Environmental Protection Agency (EPA) oversight under the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) of 1980, as amended by the *Superfund Amendments and Reauthorization Act of 1986* (SARA). Remedial actions at the site are subject to CERCLA requirements because the site is listed on the EPA National Environmental Priorities List (NPL). The DOE is also responsible for complying with the various Federal compliance acts including the *National Environmental Policy Act* (NEPA) of 1969. Section 3 of this document further discusses applicable Federal, State, and local compliance requirements and the current status of compliance activities at the Weldon Spring site.

2.2 Project Management

In order to manage the WSSRAP under the CERCLA, the proposed strategy for remedial activities at the Weldon Spring site is organized into the following four separate operable units: Weldon Spring Quarry Bulk Waste, Weldon Spring Chemical Plant, Chemical Plant Groundwater, and Quarry Residuals. The Weldon Spring Quarry bulk waste includes all wastes deposited in the quarry and their removal. The Weldon Spring Chemical Plant Operable Unit includes the buildings, soils, raffinate pits, and surface waters in the chemical plant boundary. The Chemical Plant Groundwater Operable Unit includes the groundwater at the chemical plant and vicinity areas. The Quarry Residuals Operable Unit includes the quarry groundwater; quarry basin; and groundwater, surface waters, and soils in vicinity areas.

2.3 Environmental Monitoring Program Overview

The overall goal of the WSSRAP is different from that of most of the operating and production facilities for which DOE Order 5400.1, *General Environmental Protection Program*, was developed. At the WSSRAP, environmental monitoring is conducted as required by DOE Order 5400.1 to measure and monitor effluents and to provide surveillance of effects on the environment and public health. In addition to these objectives, environmental monitoring activities support remedial activities under the CERCLA. This situation requires a careful integration of WSSRAP activities to implement, when possible, all the environmental and public health requirements of the CERCLA, and DOE and other relevant Federal and State regulations and orders.

The WSSRAP also complies with DOE Order 5400.1 requirements for preparation and maintenance of an *Environmental Protection Program Implementation Plan* (EPPIP) (Ref. 8) and the *Environmental Monitoring Plan* (EMP) (Ref. 9). The EPPIP details the programs in place at the WSSRAP to provide management direction, environmental protection goals and objectives, the remedial status of the project, and the overall frame for the protection program at the WSSRAP. The EMP details the schedule and analyses for effluent monitoring and environmental surveillance activities that are performed.

The WSSRAP environmental protection program conducts radiological and nonradiological environmental monitoring and is separated into two distinct functions: effluent monitoring and environmental surveillance. Effluent monitoring assesses the quantities of substances at the facility boundary, in migration pathways from the site, and in pathways subject to compliance with applicable regulations (e.g., *National Emission Standards for Hazardous Air Pollutants* [NESHAPs]) or permit levels and requirements (e.g., *National Pollutant Discharge Elimination System* [NPDES]). Environmental surveillance consists of analyzing environmental conditions within or outside the facility boundary for the presence and concentrations of site contaminants. The purpose of this surveillance is to detect and/or track the migration of contaminants. Surveillance data are used to assess the presence and magnitude of radiation and toxicological exposures and to assess the effects, if any, on the general public and the environment.

The WSSRAP environmental monitoring program monitors various media for radiological elements, primarily U-234, U-238, Ra-226, Ra-228, Th-228, Th-230, and Th-232. These radionuclides are the primary contaminants of concern at the Weldon Spring site. Radiological monitoring is conducted routinely at the perimeters and at off-site locations near the chemical plant and quarry for air particulates, ambient gamma radiation, and radon. Radiological monitoring is also conducted on liquid effluents in the form of NPDES discharges, streams, lakes, ponds, and groundwater wells and springs.

Nonradiological monitoring is primarily conducted at the chemical plant and quarry areas, but also includes monitoring at off-site locations to confirm that no unplanned releases have occurred. The nonradiological compounds included in the routine 1993 monitoring program are metals, inorganic ions (nitrate and sulfate), and nitroaromatic compounds. Other nonradiological compounds are monitored as part of the environmental monitoring program including asbestos at site perimeter locations, and geochemical parameters such as calcium, manganese, and sodium to assist in groundwater characterization, flow, and transport studies.

2.4 Project Accomplishments in 1993

Several activities were completed in 1993 under the overall plan for remediation of the site. All four operable units are currently active, and major accomplishments for three of the four units are detailed below. The fourth unit, the Chemical Plant Groundwater Operable Unit is in the scoping phase.

2.4.1 Weldon Spring Chemical Plant Operable Unit

A significant event for 1993 was the signing of the *Record of Decision (ROD) for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (Ref. 10) in September. The ROD presents the planned remedy for the chemical plant area, which is removal of materials, chemical stabilization/solidification of raffinate sludge and other wastes, and disposal of materials in an on-site facility.

2.4.1.1 Site Water Treatment Plant. Performance testing of the site water treatment plant was conducted during March 1993 using contaminated water from Raffinate Pit 4. Initial in-process sampling indicated levels below target and permit levels. During 1993, 15 batches of water were treated and released to the Missouri River through a permitted outfall. Various agencies have performed verification sampling of the water treated at both water treatment plants.

Design work is nearing completion for Train 2 of the site water treatment plant. Train 2 is designed to treat nitrate contaminated water in the raffinate pits. Construction of additional effluent basins for Train 2 is scheduled for 1994.

2.4.1.2 Building Dismantlement. Asbestos removal, structure and equipment dismantlement, debris cleanup, interior washdown, polychlorinated biphenyl (PCB) cleanup, and process pipe removal activities are ongoing for two building removal work packages started in 1992 and another building removal package began in 1993.

The 1.3×10^6 l (350,000 gal) water tower was razed on July 7, and the demolition of 13 buildings has been successfully and safely completed.

2.4.1.3 RCRA/TSCA Storage. The *Resource Conservation and Recovery Act* (RCRA) and *Toxic Substance Control Act* (TSCA) storage facility, Building 434, is currently being upgraded to support waste storage and operation needs. Improvements will include re-sealing the floor, adding an additional berm, reroofing, and adding a covered area outside the building for storage.

2.4.2 Weldon Spring Quarry Bulk Wastes Operable Unit

The first batch of contaminated quarry pond water was treated in the quarry water treatment plant during the fourth quarter of 1992. Sample results were well below the NPDES limits and the effluent was released January 6, 1993. During 1993, 15 batches of water were treated and released to the Missouri River through a permitted outfall.

During 1993, Phases I and II of quarry bulk waste removal were completed. Phase I began during May 1993, when the first load of surface waste material was hauled from the quarry to the wood processing site at the chemical plant. The material consisted of wood, brush, and soil left from grubbing and clearing under previous subcontracts. Phase I marked the beginning of bulk waste removal from the quarry and the first use of the quarry haul road for its design purpose.

Phase II removal activities began in August, but were suspended on September 8 due to structural failures on the stabilizer bar of the haul road trucks. The remainder of Phase II materials were hauled using alternate equipment.

A redesigned lift mechanism was installed in the haul road trucks for Phase III removal which began in December. Phase III materials consist of building rubble, soils, drummed wastes, and contaminated process equipment.

2.4.2.1 **Temporary Storage Area.** The temporary storage area was constructed in 1993 for temporary storage of quarry bulk wastes. Currently, the temporary storage area contains roll-off boxes and B-25 boxes containing arsenic contaminated wood, process pipe contaminated with product, and lead contaminated debris. In addition to container storage, approximately 1,000 loads of bulk waste from the quarry have been placed at the temporary storage area.

2.4.3 Weldon Spring Quarry Residual Operable Unit

The *Quarry Residuals Work Plan* (Ref. 11) and *Quarry Residuals Sampling Plan* (Ref. 12) were submitted and approved by the regulatory agencies during November, 1993. The characterization investigation will include sampling groundwater, surface water, soils, and sediment to determine the effect quarry bulk waste is having on the surrounding areas. Later phases of sampling will concentrate on the quarry proper after the bulk waste has been removed.

The sampling, originally scheduled for October 1993, is now scheduled for July 1994 due to flooding. See Section 10.2.2 for further discussion of the flood. Further schedule contingencies are being developed in case flooding reoccurs and access to the study areas is again closed.

2.5 Incident Reporting - Environmental Occurrences in 1993

DOE Order 5400.1 Part II, 2(b) requires reporting of environmental occurrences for the calendar year as part of the site environmental report. In 1993, 10 off-normal occurrences were categorized as environmental hazardous substances/regulated pollutants/oil releases under DOE Order 5000.3B, *Occurrence Reporting and Processing of Operations Information*. Table 2-1 lists these environmental occurrences for 1993. One occurrence involved a reportable release, and one occurrence was an NPDES permit requirement exceedance. Total estimated releases for radiological compounds were 0.1771 Ci for 1993, which included both routine and unplanned discharges. Further information is presented in Sections 4 and 6. No estimated releases were calculated for the reportable occurrences of nonradiological parameters since these parameters are not a threat to the environment or public safety.

TABLE 2-1 Environmental Occurrences CY1993

Occurrence Report Number[a]	Occurrence Date	Comments
1993-0006	02/09/93	Exceeded NPDES limit for TSS at site sewage plant
1993-0007	02/26/93	QWTP system alignment (Carbon absorption unit bypassed)
1993-0008	03/15/93	TK-501 gasket failure (spiked water spill at SWTP)
1993-0010	03/29/93	Effluent pipeline rupture at SWTP
1993-0012	04/19/93	Exceeded NPDES limit for settleable solids under the land disturbance permit for the SWTP pipeline construction.
1993-0013	04/23/93	Orange oxide spill
1993-0015	04/27/93	QWTP ion exchange unit - procedure violation
1993-0017	05/11/93	QWTP ion exchange unit - chemical spill
1993-0019	06/07/93	Ruptured pipe at SWTP
1993-0029*	07/22/93	Approximately 6.5 lbs ethylene glycol released to sump at decontamination pad (reported to off-site agencies).

* Canceled report

(a) All occurrences are off-normal

Occurrence 1993-0006 was a discharge from the outfall of the Weldon Spring site sewage plant that exceeded the NPDES permit level for total suspended solids (TSS). The NPDES limit for TSS is 15 mg/l, and sample results indicated a TSS level of 78 mg/l. The corrective measures included notifying the Missouri Department of Natural Resources (MDNR) of the sampled TSS value, shutting down the sewage treatment plant and removing the sewage by pumping to a tanker, and initiating a work package to replace the pump.

Occurrence 1993-0012 was related to storm water runoff samples for the Site Water Treatment Plant (SWTP) effluent pipeline construction area that had settleable solids of 350 ml/l/hr. The NPDES permit does not have a limit, but contains a reporting level of

2.5 ml/l/hr. Corrective measures included notifying the MDNR and increasing erosion control measures in the area.

Occurrence 1993-0029 was a release of ethylene glycol. On July 22, 1993, approximately 4 liters (approximately 1 gal or 8.5 lbs) of ethylene glycol were released to the decontamination pad. The water from the decontamination pad is pumped to the equalization basin at the site water treatment plant. Process engineers at the WSSRAP indicated that the treatment process should be highly effective in removing trace concentrations of ethylene glycol from the contaminated water in the equalization basin.

The release was originally classified according to DOE Order 5000.3B, which requires reporting a release of ethylene glycol in excess of 100 pounds. The PMC mistakenly assumed that this quantity was also the CERCLA reportable quantity (RQ). On August 16, 1993, during the normal review of Material Safety Data Sheets, Waste Management personnel discovered that the RQ for ethylene glycol is 0.454 kg (1 lb). The release was then reported to the National Response Center and the Missouri Department of Natural Resources.

2.6 Special DOE Order Related Programs

In addition to the direct program requirements and documentation required under DOE Order 5400.1, the DOE Order specifically requests that other programs be presented in the *Site Environmental Report*, including the groundwater protection management program, the meteorological monitoring program, and the waste minimization and pollution prevention program. This section also addresses other programs, including the radiological control program, self assessments under DOE Order 5482.1B, and the surface water management program in place at the WSSRAP to support the environmental protection program.

2.6.1 Groundwater Protection Management Plan

The WSSRAP has a formal groundwater protection and management program in place, and policies and practices are documented in the *Groundwater Protection Program Management Plan* (Ref. 13). The plan outlines how monitoring programs will be developed to assess the nature and extent of contaminants in the groundwater, to evaluate potential impacts on public health, and to gather data for remedial decisions. All policies pertaining to groundwater monitoring, including well installation, decontamination, construction, sampling methods, and abandonment methods, are detailed in this plan.

The *Groundwater Protection Program Management Plan* also outlines the hydrogeological characterization program conducted as part of CERCLA activities. These include fundamental methods such as groundwater sampling, water level monitoring, slug tests, tracer tests, and geologic logging.

2.6.2 Meteorological Monitoring Program

A meteorological station is located at the chemical plant to provide data to support the environmental monitoring programs. The meteorological station provides data on wind speed, wind direction, ambient air temperature, barometric pressure, and precipitation accumulation. Data from this station are used to assess meteorological conditions and air transport and diffusion characteristics which determine possible impacts of airborne releases. In addition, precipitation data are used to correlate water level fluctuations and contaminant concentrations in surface water and groundwater wells.

2.6.3 Surface Water Management Program

The WSSRAP maintains a surface water management program to ensure effective implementation of policies detailed in DOE Order 5400.5 and documented in the *Surface Water Management Plan* (Ref. 14). This program also incorporates the as-low-as-reasonably-achievable (ALARA) concept in the execution of the program.

This plan identifies existing and potential water sources, water quality categories, and also provides the requirements and methodologies for proper control, management, and disposition of site waters. Erosion and water control, and water management for the quarry and site water treatment plants are also discussed in the plan. The key elements of the plan are source identification, characterization, monitoring, engineering controls, and management methods. To date, more than 500 controlled releases of water have been managed through this program.

2.6.4 Radiation Protection Program

The *U.S. Department of Energy Radiological Control Manual* (RADCON) (Ref. 15), specifies how the DOE expects all facilities and contractors to conduct and manage their radiation protection programs. RADCON expands upon 10 CFR 835, which was issued in December 1993 in the Federal Register and sets the minimum acceptable radiological control standards for DOE facilities. The manual contains requirements for all aspects of radiation protection, including protective measures for internal and external contamination control, ALARA practices, dosimetry, protective clothing and equipment, instrumentation and calibration, worker training, warnings and sign postings, survey procedures, waste management, environmental surveillance, and shipping and receiving. The DOE's objective in preparing this manual was to ensure that radiation protection programs and worker training are consistent among DOE facilities.

The WSSRAP is in compliance with approximately 65% of the provisions in the manual and has an aggressive implementation plan and schedule for meeting compliance with the remaining provisions. The WSSRAP has formed a RADCON Implementation Team, which includes representatives from all affected departments and is responsible for ensuring that actions necessary to attain compliance are completed as scheduled.

2.6.5 Waste Management Program

The waste management program characterizes hazardous chemicals and wastes found on site to secure and store these wastes properly. This program also consolidates the packaging and shipping of hazardous waste samples. Hazardous and mixed wastes are stored in the on-site RCRA and TSCA storage facility, Building 434, and at the asbestos storage area (ASA) and temporary storage area (TSA) until a final treatment or disposal option is available. The WSSRAP has not shipped any RCRA waste off site and therefore has not been required to comply with RCRA manifest or biennial report requirements. Although not required, the biannual report was submitted to MDNR as a courtesy.

Waste minimization and pollution prevention activities at the Weldon Spring site have been combined and are described in the *Waste Minimization/Pollution Prevention Awareness Plan* (Ref. 16). The key elements of this program are chemical control, training and awareness, work activity review, and a recycling program.

2.6.6 Self-Assessment Program

The WSSRAP complies with the guidelines presented in DOE Order 5482.1B for a self-appraisal and assessment program. The self-assessment program is conducted by department managers to verify their department's compliance with the requirements of the quality assurance program. During 1993, the self assessment program was assessed and an action plan developed to correct deficiencies. A number of documents, procedures, programs, activities, and training programs were developed, implemented, and performed. A detailed description of the program can be found in the *Self-Assessment Program Implementation Plan* (Ref. 17).

There were two self-assessments conducted at the WSSRAP, although no environmental self-assessments were conducted during 1993.

2.6.7 Training

Training is a key element of the environmental protection program. Through training, each employee is instructed in the policies and procedures related to environmental protection.

The training program can essentially be broken into four main areas: (1) documents, (2) procedures, (3) special courses taught on site to convey specific policies or issues and, (4) off-site courses designed to provide instruction for specific areas. Department managers establish unique training matrixes for each employee to ensure a comprehensive understanding of position requirements and overall policies and program requirements.

The status of employee training is reported to department managers and individual employees six times a year. These bimonthly reports include status of documents and procedures reviewed and training programs and off-site courses taken during the current year.

3 COMPLIANCE SUMMARY

3.1 Compliance Status for 1993

The Weldon Spring site is listed on the National Priorities List (NPL), and therefore the Weldon Spring Site Remedial Action Project (WSSRAP) is governed by the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) process. Under the CERCLA, the WSSRAP is subject to meeting or exceeding the applicable or relevant and appropriate requirements of Federal, State, and local laws and statutes, such as the *Resource Conservation and Recovery Act* (RCRA), the *Clean Water Act* (CWA), the *Clean Air Act* (CAA), the *Toxic Substance Control Act* (TSCA), the *National Historic Preservation Act* (NHPA), the *Safe Drinking Water Act* (SDWA), and Missouri regulations. Because the DOE is the lead agency for the site, the procedural and documentation requirements of the *National Environmental Policy Act* (NEPA) must also be met, as well as the requirements of U.S. Department of Energy (DOE) Orders. Section 3.1.1 is a summary of WSSRAP compliance with applicable Federal regulations, and Section 3.1.2 is a summary of the WSSRAP compliance with major DOE Orders.

3.1.1 Regulatory Compliance Status

Comprehensive Environmental Response, Compensation and Liability Act

The WSSRAP has integrated the procedural and documentation requirements of the CERCLA, as amended by the *Superfund Amendments and Reauthorization Act* (SARA), and the NEPA, as required by the policy stated in DOE Order 5400.4. For example, *Engineering Evaluation/Cost Analyses* (EE/CAs) and *Remedial Investigation/Feasibility Study* (RI/FS) documents including (RI/FS) work plans, which are CERCLA documents, contain the required NEPA information for *Environmental Assessments* (EAs) and *Environmental Impact Statements* (EISs).

The WSSRAP used NEPA and CERCLA supporting documentation to prepare the *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (ROD) (Ref. 10). The ROD was signed in September 1993 by the Environmental Protection Agency and the Department of Energy. This decision document presents the selected remedial action for the chemical plant area of the Weldon Spring site. The preferred remedy for the chemical plant area of the Weldon Spring site is removal, chemical stabilization/solidification, and disposal on site.

The CERCLA and the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP) spell out responsibilities and requirements for natural resource trustees. As lead Natural Resource Trustee for the WSSRAP, the DOE notified the co-trustees that potential off-site releases of hazardous substances may have occurred and that environmental restoration activities are proceeding. Neither of the co-trustees, the Department of the Interior and the Missouri Department of Natural Resources (MDNR), has responded to date.

National Environmental Policy Act

During 1993, three categorical exclusions were prepared for the site. These exclusions were prepared for a physical testing trailer, office trailers, and a wildlife habitat improvement project. The categorical exclusions for the physical testing trailer and the additional office trailers were approved. The third exclusion for the wildlife habitat improvement project was reviewed by the DOE-Oak Ridge Operations office and was determined to be within the scope of previously approved NEPA documents.

Resource Conservation and Recovery Act

Hazardous wastes at the Weldon Spring site are managed as required by the RCRA (as substantive applicable or relevant and appropriate requirements [ARARs]). This includes characterization, consolidation, inventory, storage, and transportation of hazardous wastes that remained on site after closure of the Weldon Spring Uranium Feed Materials Plant (WSUFMP) and wastes that were generated during remedial activities.

A RCRA storage, treatment, and disposal permit is not required at the site since remediation is being performed in accordance with decisions reached under the CERCLA. Section 121(e) of the CERCLA states that no Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely on site.

The RCRA was amended by the Federal Facility Compliance Act (FFCA), which was enacted on October 6, 1992. The FFCA waives sovereign immunity for fines and penalties for RCRA violations at Federal facilities. However, a provision postpones that waiver for 3 years for mixed waste Land Disposal Restriction storage prohibition violations at DOE sites and requires the DOE to prepare plans for developing the required treatment capacity and treatment technologies for mixed wastes. Each plan must be approved by the State or the U.S. Environmental Protection Agency (EPA), after consultation with other affected States and consideration of public comment, and an order issued, by the regulator, requiring compliance with the plan.

The DOE published a schedule for the submittal of the plans for the treatment of mixed waste in the April 6, 1993, Federal Register. The published schedule specifies that DOE sites will provide the site treatment plans in three phases; the "conceptual plan" by October 1993, a "draft plan" no later than August 1994, and a "final proposed plan" no later than February 1995.

The Weldon Spring site submitted its conceptual site treatment plan to the Missouri Department of Natural Resources and the Environmental Protection Agency on October 28, 1993.

Currently, two underground storage tanks that contained gasoline and diesel fuel remain on site. The tanks are scheduled to be closed appropriately during removal of the building foundations.

RCRA groundwater monitoring for regulated units is discussed in detail in Chapter VII.

Toxic Substances Control Act

Polychlorinated biphenyls (PCBs) that have been removed from service for storage and disposal activities are managed in accordance with 40 CFR Part 761 (TSCA).

Clean Air Act

CAA compliance requirements pertaining to the site are found in Title I - Nonattainments, Title III - Hazardous Air Pollutants (including National Emission Standards for Hazardous Air Pollutants [NESHAPs]) and Title VI - Stratospheric Ozone Protection. NESHAPs dose calculations for 1993 indicate the highest receptor location was below the NESHAPs standard of 0.1 mSv (10 mrem).

St. Charles County is classified in the Federal Register of November 6, 1991, 56 FR 215 as a moderate nonattainment area for ozone. As a moderate ozone nonattainment area, the requirements would affect sources emitting nitrogen oxide (NO_x) and volatile organic compounds (VOCs). At present, sources described above do not exist at the WSSRAP.

Under Title III, asbestos and radionuclides are hazardous air pollutants. The standards establish maximum levels for radionuclides and asbestos. WSSRAP plans for monitoring radionuclides and asbestos have been approved by the EPA and are described in detail in Section 5, along with the 1993 status of the monitoring. Table 3-1 lists the major source categories that could potentially apply to the WSSRAP along with the respective schedules for promulgation of the corresponding emission standards.

TABLE 3-1 Potentially Applicable Major Source Categories

Major Source Category	Schedule Date
Gasoline distribution	11/15/94
Solid waste treatment, storage, and disposal facilities	11/15/94
Site remediation	11/15/00

Currently, the potential major source categories existing at the WSSRAP do not exceed the threshold limits of 9.07 metric tons per year (tpy) (10 tpy) of any single hazardous air pollutant or 22.7 metric tpy (25 tpy) of a combination of hazardous air pollutants; nor does the project currently store over 3,780 liter (1,000 gal) of gasoline per container on site. Therefore, the project is not subject to the requirement for vapor recovery systems for gasoline distribution. However, the Project Management Contractor (PMC) will continue to monitor the various sources for applicability. The categories of radionuclide emitters are not yet listed because the criteria for defining major and area sources of these pollutants have not been selected. Upon proposal of the Maximum Available Control Technology standards, the WSSRAP will develop appropriate plans and budgets to comply with the standard for each of these source categories.

Sections 608 and 609 of Title VI are applicable to the WSSRAP. Section 608 establishes requirements for national recycling and emission reduction of Class I and II substances (chlorofluorocarbons and hydrochlorofluorocarbons, respectively). The section makes it unlawful to release, vent, or dispose of any Class I or II substances. Requirements in

Section 608 apply to servicing, repairing, maintaining, and disposing of any refrigeration system (old or new) or air conditioning system (old or new). Section 609 specifies requirements that pertain to servicing motor vehicle air conditioners and applies to all WSSRAP vehicles. The WSSRAP is complying with Sections 608 and 609 of Title VI of the 1990 CAA amendments by (1) implementing a phase-out policy of ozone-depleting substances by instituting controls in the purchasing and use of these substances; and (2) obtaining copies of the personnel training certifications and equipment approval records for personnel and subcontractors that service any WSSRAP ozone-containing equipment (i.e., refrigerators, heating, ventilating, and air conditioning [HVAC] units, abandoned refrigeration units, etc.) or any WSSRAP vehicle cooling system.

Clean Water Act

Effluents discharged to waters of the United States are regulated under the CWA through regulations promulgated and implemented by the State of Missouri. The Federal government has granted regulatory authority for implementation of CWA provisions to those states with a regulatory program that is at least as stringent as the Federal program.

Compliance with the CWA at the WSSRAP includes meeting parameter limits set in six National Pollutant Discharge Elimination System (NPDES) permits. Both effluent and erosion-control monitoring are performed. Section 3.3 offers further details on the NPDES permits.

The first batch of contaminated quarry pond water was treated in the quarry water treatment plant during the fourth quarter of 1992. The sample results were well below the NPDES limits and the effluent was released January 6, 1993. During 1993, 15 batches of treated effluent were discharged through the NPDES outfall.

Construction of a water treatment plant at the chemical plant was completed in 1992. This plant has been designated as the Site Water Treatment Plant - Train 1. This Train 1 plant treats water from Raffinate Pit 4, shower and decontamination water generated during building dismantlement activities, and runoff from the temporary storage area (TSA). During 1993, 15 batches of treated effluent were discharged through the NPDES outfall.

The final construction design for the Site Water Treatment Plant - Train 2 is being completed, and construction is scheduled to begin in 1994. Train 2 is designed to treat the nitrates from the raffinate pits.

Rivers and Harbors Act

During 1993, one nationwide permit was applied for under Section 10 of the *Rivers and Harbors Act* and Section 404 of the *Clean Water Act*. The permit was for the proposed elimination of 0.9 ha (2.2 acres) of delineated wetland in the soils borrow area. The lost acreage is to be mitigated on Missouri Department of Conservation land in the northeast corner of the August A. Busch Memorial Conservation Area as part of a 23.1 ha (57 acre) waterfowl habitat project.

Federal Insecticide, Fungicide, and Rodenticide Act

The WSSRAP maintains compliance with *Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA) requirements through inspection of controlled pesticide/herbicide storage areas. To date, no application of restricted-use pesticides has occurred. The site is currently in the process of training and certifying two applicators.

Department of Transportation

Pursuant to HM-181, the WSSRAP conducted on-site training on the *Hazardous Material Transportation Act*. The training targeted personnel with responsibilities for hazardous materials transportation. The training covered classification of hazardous materials by new shipping names, new performance based packaging requirements, new requirements for marking, labeling and placarding, and proper segregation and modes of transportation.

Safe Drinking Water Act

Currently, the SDWA is not an ARAR at the WSSRAP. The SDWA will be evaluated for its applicability during the decision-making process for the groundwater and quarry residuals operable units.

Emergency Planning and Community Right-to-Know Act

In 1992, the Secretary of Energy established DOE's voluntary participation in the Section 313 of the *Emergency Planning and Community Right-to-Know Act* (EPCRA) for toxic release inventory (TRI) reporting and the 33/50 pollution prevention (PPA) program.

In March 1993, guidance was distributed to all DOE facilities which established 1993 as the first year for gathering data with the first report due in July 1994.

On August 3, 1993, the President signed Executive Order 12856 directing Federal Facility compliance with the EPCRA and the PPA.

The site is developing a program to achieve compliance with the Executive Order and to file the first TRI report, if required, in 1994.

National Historic Preservation Act

The expansion of the soils borrow area and haul road required study for potential cultural resources. An archeological review of the expanded soils borrow area and haul road is in progress. In addition to the Phase I survey (initial evaluation) of the expanded areas, a Phase II survey (determination of eligibility for nomination to the National Register) is in progress for all sites identified in the 1992 Limited Area Phase I Survey.

The *Mitigation Action Plan for Remedial Actions at the Chemical Plant* (Ref. 19) area specifies that any sites eligible for nomination to the National Register will be preserved through data recovery or avoidance if impacted by the borrow area or haul road development. This work is ongoing and will extend into 1994.

On March 4, 1993, the State Historic Preservation Officer for Missouri was advised under the provision of 36 CFR Part 800.5 that a "no effects" determination on historic or prehistory properties was made for the elimination of the four man-made ponds and surrounding wetlands in the borrow area. The State Historic Preservation Officer's review period expired with no comments or rebuttal to the determination.

Upon completion of the Phase II survey, and where data recovery is necessary, the Officer will again be consulted and final clearance received.

Endangered Species Act

The U.S. Fish and Wildlife Service was consulted under Section 7 of the *Endangered Species Act* for the soils borrow area and haul road. The Missouri Department of Conservation (MDC) was also contacted regarding State-listed threatened and endangered species. Through surveys of the affected areas a determination was made that while the State listed Cooper's hawk was observed in the area there would be no loss of critical habitat and no effect on the species. There were no other listed species found in the affected areas and no critical habitat exists in those areas.

Executive Order 11988 Floodplain Management

Completion of the site water treatment plant effluent discharge pipeline, described in the 1992 annual site environmental report, was delayed for the entire year due to an unseasonably cold, wet spring marked by high waters. Heavy, above normal rainfalls swelled the Missouri River, flooding the outfall area. It is anticipated this construction project will be completed in the first half of 1994, providing the Missouri River remains at the normal level.

Argonne National Laboratory (ANL), under contract to DOE Weldon Springs, reviewed the proposed area for the wetland mitigation project described in the *Rivers and Harbors Act* section of this report. The DOE-OR determined that while the project is in the 100 year floodplain of Dardenne Creek, as shown on the St. Charles County floodplains maps (Ref. 18), the requirements of 10 CFR 1022 do not apply. Using the State and U.S. Army COE procedures, the permit for this action was obtained by the MDC concurrently with the site *Clean Water Act* Section 404 permit application.

Executive Order 11990 Protection of Wetlands

A wetlands assessment and delineation for the soils borrow area, borrow area haul road, and the designated mitigation area at the Busch Memorial Conservation Area was performed during 1993. The *Clean Water Act* Section 404 permit application described in the *Rivers and*

Harbors Act and Floodplain Protection sections of this report was prepared following the procedures and requirements contained in 10 CFR 1022 and U.S. Army COE requirements.

The delineations show approximately 0.9 ha (2.2 acres) of wetlands will be impacted in the soils borrow and haul road area development. The Wetlands Project Plan for the COE permit application shows a 2 to 1 mitigation for the replacement of impacted wetlands (Ref. 47). Full details are provided in the *Mitigation Action Plan for the Remedial Action at the Chemical Plant Area* (Ref. 19).

3.1.2 DOE Order Compliance

3.1.2.1 DOE Order 5400.5, Radiation Protection of the Public and the Environment. DOE Order 5400.5 establishes nine primary standards and requirements for DOE operations to protect members of the public and the environment against undue risk from radiation. The DOE operates its facilities and conducts its activities so that radiation exposures to members of the public are maintained within established limits.

The annual dose to the maximally exposed member of the public as a result of activities at the Weldon Spring site was below the 100 mrem (1 mSv) guideline for all potential exposure modes. The 10 mrem (0.1 mSv) annual dose limit for public exposure to airborne emissions, excluding radon and its respective decay products as specified in 40 CFR Part 61, *National Emission Standards for Hazardous Air Pollutants*, was not exceeded in 1993. The appropriate dose evaluation techniques were used to assess 1993 environmental monitoring and surveillance data in compliance with this requirement.

Storm water runoff exceeded the derived concentration guideline (DCG) of an annual average of 600 pCi/l for uranium at outfalls NP-0001 and NP-0003. The annual average concentration for uranium was 1,003 pCi/l at outfall NP-0001 and 607 pCi/l at NP-0003. The increase to above the DCG may be due to a number of factors including a higher than normal annual precipitation, upstream building demolition and increased inflow from an upstream source into the abandoned process sewer that leads to NP-0001. The increase at NP-0003 was believed to be the result of the above average annual precipitation which caused Ash Pond to discharge for a much greater portion of the year than in past years. Ash Pond flow contributes to NP-0003 and is usually much higher than the other contributing streams. Based on upstream monitoring, mitigative measures are being taken to reduce the uranium levels.

Eight out-of-service vehicles were surveyed and released from the WSSRAP in April 1993. A comprehensive radiological survey was performed on each vehicle, and they met the DOE release guidelines as specified in this order for release of real property, personal property, and materials and equipment. Therefore, the vehicles were released for unrestricted use.

Records of all environmental monitoring and surveillance activities conducted at the Weldon Spring site in 1993 are being maintained in accordance with the requirement of this order. All reports and records generated at the WSSRAP in 1993, pursuant to DOE Order requirements, presented data in the units specified by the applicable regulation or order.

3.1.2.2 DOE Order 5820.2A, Radioactive Waste Management. DOE Order 5820.2A establishes policies, guidelines, and minimum requirements by which the DOE manages its radioactive and mixed waste and contaminated facilities. The Weldon Spring site was in compliance with the applicable portions of Chapter III (low-level waste), Chapter V (decommissioning of radioactively contaminated facilities), and Chapter VI (administrative activities related to the *Waste Management Plan* [Ref. 20]). The types of wastes addressed in Chapters I, II, and IV were not present at the site.

3.1.2.3 DOE Order 5400.1, General Environmental Protection Program. The WSSRAP conducted both radiological and nonradiological environmental monitoring programs at the site and vicinity properties. Environmental monitoring required by DOE Order 5400.1 was conducted to measure and monitor effluents and to provide surveillance of their effects on the environment and public health.

The WSSRAP was in compliance with Order 5400.1 requirements for preparation of an *Environmental Protection Program Implementation Plan* (EPPIP) (Ref. 8). The EPPIP details the programs in place at the WSSRAP to provide management direction, environmental protection goals and objectives, and the overall framework for the protection program at the WSSRAP. The project has prepared an *Environmental Monitoring Plan* (Ref. 9) which is reviewed annually and revised as necessary.

In addition to the plans developed for overall environmental monitoring and protection, the WSSRAP annually reviews and revises, as necessary, the *Groundwater Protection Program*

Management Plan (Ref.13) and the *Waste Minimization and Pollution Prevention Awareness Plan* (Ref. 16).

3.1.2.4 DOE Order 5400.3, Hazardous and Mixed Waste Program. DOE Order 5400.3A mandates management of radioactive and hazardous wastes. At the WSSRAP, radioactive hazardous and mixed wastes were managed in a manner that provided protection of the environment and protection of the health and safety of the public and site personnel. Implementation of the Order is described in the *Waste Management Plan* (Ref. 20).

All waste management activities including generation, characterization, storage, packaging, minimization, transportation, and treatment or disposal were accomplished in a manner that was consistent with these broad objectives. Waste management activities were conducted in compliance with all applicable laws, requirements, regulations, and good practices governing the management of hazardous, radioactive, mixed and uncontaminated, nonhazardous waste. The WSSRAP Waste Management Program has been developed to ensure that the objectives of these orders are achieved and that waste generation is minimized.

3.1.2.5 DOE Order 5480.1B, Environment, Safety, and Health Program for Department of Energy Operations. DOE Order 5480.1B mandates (1) protection of the environment and the health and safety of the public, (2) assurance of safe and healthful workplaces and conditions of employment for all employees of DOE and DOE contractors, (3) protection of government property against loss and damage, (4) compliance with applicable statutory requirements, and (5) presence of a quality assurance program to ensure quality of design and standards.

Implementation of these requirements is described in the *Environmental Protection Program Implementation Plan* (Ref. 8). The plan describes DOE activities and CERCLA requirements, activities, and functions concerned with controlling air, water, and soil pollution, and limiting the risks to personnel and the public. The activities include, but are not limited to, environmental protection, occupational safety, industrial hygiene, health physics; emergency preparedness; radioactive, hazardous, and mixed waste management; and quality assurance.

3.1.2.6 DOE Order 5480.4, Environmental Protection, Safety, and Health Protection Standards. DOE Order 5480.4 requires the WSSRAP to comply with all applicable

DOE Orders and guidelines and Federal, State, and local regulatory requirements. This summary describes compliance activities and status.

3.2 Current Issues and Actions

3.2.1 Current Issues

3.2.1.1 National Emission Standards for Hazardous Air Pollutants Compliance. The WSSRAP has developed an alternate method for National Emission Standards for Hazardous Air Pollutants (NESHAPs) point source monitoring and compliance as provided in 40 CFR 61.93 (b)(5), whereby air concentrations were monitored at five designated critical receptor locations on and around the Weldon Spring site. The WSSRAP plan is contained in the *Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 21), which has been approved by the EPA. The EPA has also approved the WSSRAP plan to report annual monitoring results and effective dose equivalents at critical receptor locations via the annual site environmental report.

3.2.2 Current Actions

3.2.2.1 Release Reporting. On July 22, 1993, approximately 3.8 kg (8.5 lbs) of ethylene glycol was released to the sump at the decontamination pad. This release exceeded the reportable quantity for ethylene glycol under the CERCLA, which is 0.45 kg (1 lb). The release was reported to off-site agencies on August 16, 1993, as a release of a reportable quantity. Additionally, the release was reported to the DOE, under DOE Order 5000.3B, but since the quantity did not meet the 45 kg (100 lb) reporting requirements for the DOE, the report was canceled. Additional releases of reportable quantities of ethylene glycol occurred on December 6 and December 30. These releases were reported to off-site agencies as a release of a reportable quantity, but did not meet the reporting requirements for the DOE.

3.2.2.2 Functional Appraisal - Environment, Safety and Health, and Quality Assurance. A functional appraisal of selected environmental, safety, health, and quality assurance programs, and Conduct of Operations was conducted at the WSSRAP by the DOE Oak Ridge Operations Office from May 4 to May 12, 1993. The appraisal was performed to assist the WSSRAP in its self-assessment program. No tiger-team audits were conducted in 1993 for environmental issues.

Table 3-2 summarizes the number of deficiencies resulting from the functional appraisal of selected environmental safety, health, and quality assurance programs. Thirty-one of the 73 deficiencies have been closed out and are awaiting DOE approval and closeout.

TABLE 3-2 Results of Oak Ridge Functional Appraisal

	New Deficiencies Cited	Previous Deficiencies Open	Audit Findings Closed
Water Pollution Control	5	0	3
Environmental Quality Assurance	9	1	7
Groundwater Programs	4	0	2
Waste Minimization	8	0	0
Asbestos Management	3	0	2
Radiological Monitoring	7	2	3
Toxic and Hazardous Substance Control	3	1	1
Radioactive Waste Management	0	0	0
Natural Historic Preservation Act	N/A	N/A	N/A
Health Physics	3	0	1
Industrial Hygiene	4	0	0
Industrial and Construction Safety	6	6	8
Transportation Safety	1	0	0
Fire Protection	1	4	2
Conduct of Operations	3	2	2
Total	57	16	31

3.2.2.3 Missouri Department of Natural Resources Hazardous Waste Inspection. The Missouri Department of Natural Resources conducted an inspection under the authorization of the *Resource Conservation and Recovery Act* on June 2-3, 1993. The inspection resulted in five findings. The findings are outlined in Table 3-3. Two of the findings were disputed, two have been corrected, and one of the findings is being corrected under the Building 434 improvements work package and is scheduled for completion in 1994.

TABLE 3-3 Results of MDNR Hazardous Waste Inspection

Finding	Corrective Action Date
1. Base of containment system not impervious and free of cracks at Building 434.	04/04/94
2. Failure to use consecutive shipment numbers on manifests.	Finding disputed - WSSRAP has not shipped RCRA wastes off-site.
3. Failure to file an updated generator registration form.	07/21/93
4. Contingency Plan did not contain all correct names, addresses, and telephone numbers of emergency coordinators.	10/30/93
5. Contingency Plan did not have an evacuation plan included.	Finding disputed - evacuation plan was in Contingency Plan.

3.3 Summary of Permits for 1993

Various permits were maintained by the WSSRAP for remedial activities including NPDES, excavation, and floodplain permits. Table 3-4 provides a summary of all NPDES and Construction Permits. Currently, three active NPDES permits cover discharges from the site water treatment plant (MO-01077701), quarry water treatment plant (MO-0108987), and storm water discharges from the site water treatment plant pipeline excavation (MO-R101389). Table 3-4 shows that the permit for the site water treatment plant has expired; however, the site has applied for renewal of the permit and is awaiting final permit approval from the State. A nationwide permit under the *Rivers and Harbors Act* and *Clean Water Act* has been issued by the Department of the Army for the proposed elimination of 0.9 ha (2.2 acres) of delineated wetland in the soils borrow area.

3.4 Site Remedial Mitigation Action Plan

The *Mitigation Action Plan for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site* (MAP) (Ref. 19) was issued in November 1993, to summarize the major environmental impacts requiring mitigation as indicated in the RI/FS (Ref 2) and *Record of Decision* (Ref. 10) for the chemical plant operable unit. The MAP further presents the monitoring and reporting requirements for mitigative measures committed to the *Record of Decision*.

TABLE 3-4 Summary of WSSRAP NPDES and Construction Permits

Permit No.	(a)	Date Issued	Date Expired	(b)	Date Renewal or Extension Request Due	Scope and Comments
MO-0107701	O	10/01/90	07/28/93	N	01/28/93	Reapplication submitted 01/28/93. Covers storm water, sanitary, and SWTP discharges.*
MO-0108987	O	05/05/89	05/04/94	N	12/04/93	Covers QWTP discharge.
MO-G680001	O	12/19/91	05/16/96	N	Terminated	Covers hydrostatic test water from QWTP. QWTP tanks and effluent Pond 2 are excluded since they have held contaminated water.
MO-G680002	O	02/07/92	05/16/97	N	Terminated 09/06/93	Covers hydrostatic test water from SWTP tanks, basins, etc.
MO-G680004	O	02/07/92	Terminated 02/08/93	N	Terminated 02/08/93	Covered hydrostatic testing of QWTP effluent pipeline. The pipeline has carried treated water, so the permit is no longer applicable.
MO-G680005	O	11/06/92	05/16/96	N	Terminated 06/08/93	Covers hydrostatic test water from SWTP effluent pipeline.
MO-R101389	O	12/07/92	12/12/96	N	06/12/96	Covers land disturbance storm water discharges from the SWTP pipeline excavation.
22-4245	C	08/01/91	08/01/93	Y	07/01/93	SWTP basins, siltation basins, effluent pump station, etc.
2523	C	04/10/92	04/10/93	N	03/10/93	SWTP Train 1
22-4113	C	06/07/90	06/06/92	Y	NA	QWTP basins, effluent pump station. Construction complete.
22-4233	C	04/17/91	10/16/92	Y	NA	QWTP, construction complete.
22-4411	C	08/12/92	08/11/93	N	07/11/93	Flow equalization on sanitary plant.
22-4450	C	09/28/92	09/27/93	N	08/27/93	SWTP effluent pipeline.

(a) Permit type, O = Operating, C = Construction
(b) Permit extended? N = No, Y = Yes
QWTP Quarry Water Treatment Plant
SWTP Site Water Treatment Plant
* See Section 3.5

The MAP was submitted to EH-1 on December 13, 1993, for signature, which started a yearly report requirement. This annual report requirement will be met by submitting this report and will address the effectiveness of the mitigative measures taken during the previous year.

As required by the *Mitigation Action Plan for the Remediation of the Chemical Plant Area of the Weldon Spring Site* (Ref. 19), a plan is being prepared which outlines measures to protect the workers, the public, and the environment during remedial activities at the chemical plant. The proposed protective measures include dust, noise, radon, air particulate, groundwater, surface water, erosion control, and wetlands monitoring. The results of these monitoring activities will be presented in the annual site environmental reports.

All remedial activities will be conducted in accordance with project Health and Safety Plans (HASPs) to ensure worker protection. Noise monitoring will be performed during construction activities in accordance with procedure ES&H 3.1.7. Equipment and surrounding areas will be monitored to identify noise levels above 90 decibels. If it is determined that excessive noise levels are sustained over a period of time, noise level monitoring may be employed during work activities at nearby residential areas and at some radius from the construction area for recreational area users.

Fugitive dust emissions will be monitored in accordance with the HASPs established for the borrow area and cell construction work activities. The HASPs generated for site activities state that total airborne dust concentrations, as measured in the work area, shall at no time exceed a limit of 1 mg/m^3 (visible dust).

The *Environmental Monitoring Plan* (Ref. 9) outlines the groundwater, surface water, and air monitoring which will be employed to monitor the protection of the environment and the pubic. Impact to the perched groundwater could possibly occur during deep foundation removal. Monitoring will be increased if it is determined that foundation removal could be impacting groundwater.

The erosion control program will be conducted in accordance with procedure ES&H 4.2.1 to confirm that the structures are working adequately to reduce sediment runoff to nearby surface waters and wetlands. A NPDES construction permit will be obtained for the borrow area and a limit of settleable solids will be imposed. When foundation and contaminated soil removal begins, additional parameters will be monitored at those NPDES outfalls which will receive runoff from the work area.

Contaminated surface water runoff will be monitored under the *Storm Water Runoff Sampling Plan* (Ref. 54). This plan requires surface water runoff from construction and storage areas be collected and analyzed for total uranium and settleable solids in an effort to determine the effectiveness of temporary erosion control measures.

Radon and particulate emissions will be monitored using the three tier program as outlined in the *Environmental Monitoring Plan*. This program meets the requirements of DOE Orders 5400.1 and 5400.5. The three tiers are site specific, perimeter, and critical receptor monitoring for radioactive air particulates, radon, and dust.

Monitoring associated with the redevelopment of a new wetlands complex as a mitigation measure for the elimination of wetlands at the borrow area will include monthly sampling of hydrological parameters, annual vegetation surveys, spring/fall bird surveys, and spring/summer herpetofauna surveys.

3.5 Compliance Status for the Period January 1 - April 15, 1994

Compliance status remained unchanged under the RCRA, the CAA, the *Endangered Species Act*, the *National Historic Preservation Act*, Executive Orders 11988 and 11990, and DOE Orders.

Comprehensive Environmental Response, Compensation and Liability Act

The following CERCLA documents have been completed and submitted during 1994:

- January 25: The *Quarry Bulk Waste Remedial Action Work Plan* (Ref.48) was revised and forwarded to DOE.
- March 10: The responsive report to the EPA's comments on the CSS pilot-scale facility was provided to DOE.

Clean Water Act

A public meeting was held on February 17, 1994, to seek public comments on the reissuance of the NPDES permit for discharging water from the site (chemical plant) water treatment plant. Approximately 65 people representing the general public, the WSSRAP, and the MDNR attended the public meeting. The NPDES permit for the site water treatment plant was reviewed on March 4, 1994.

Toxic Substances Control Act

On January 27, 1994, approximately 56.8 l (15 gal) of PCB contaminated oil leaked from materials which were abandoned in Raffinate Pit 4 approximately 30 years ago. The materials include discarded equipment and storage barrels whose contents may or may not be empty. Due to the disarray of the barrels and high water levels of the storage pond, the exact location of the leak cannot be determined. However, the leak has been contained and efforts to absorb the oil, where practical, have been initiated. The storage pond was built with a clay bottom to store raffinate sludge and has no drainage outlet. Since the spill was directly into surface waters the spill was reported to EPA Region VII and the National Response Center as required by 40 CFR 761.125.

Rivers and Harbors Act

In March 1994, the Corps of Engineers approved the nationwide permit for the elimination of 0.9 ha (2.2 acres) of delineated wetland in the soils borrow area.

Site Remedial Mitigation Action Plan

On March 7, 1994, the Army Corp of Engineers approved a Section 404 permit application submitted by the Missouri Department of Conservation (MDC) to create a 23.1 ha (57 acre) wetland and waterfowl habitat adjacent to Dardenne Creek within the boundaries of the August A. Busch Memorial Conservation Area.

On March 11, 1994, the WSSRAP application for Nationwide Permit 26 was approved, subject to the establishment of an agreement between the DOE and the MDC. The mitigation agreement states that the DOE will provide funding for the construction of the 23.1 ha (57 acre) wetland and waterfowl complex at the Busch Conservation Area to meet wetland mitigation requirements in exchange for wetland mitigation credit as defined in the *Mitigation Action Plan for the Remediation of the Chemical Plant Area of the Weldon Spring Site* (Ref. 19).

The Phase I and Phase II archaeological survey for the entire borrow area and haul road corridor was completed in December 1993. The report from Dr. Gary Walters, Triad Research Incorporated, will be finalized and transmitted to the State of Missouri and the site in April-May. Preliminary verbal reports indicate only one site will require Phase II data recovery or avoidance. The site is located in an area of the borrow area where avoidance is a realistic alternative.

4 RADIATION DOSE ANALYSIS

This section evaluates airborne monitoring results and surface and groundwater discharges of radiological contaminants. The evaluations presented include potential calculated dose equivalents to the general public and doses to aquatic biota. These calculations are evaluated against U.S. Department of Energy (DOE) guidelines contained in the *U.S. Department of Energy Radiological Control Manual* (Ref. 15) and in DOE Order 5400.5.

Dose calculations are presented in this section for each of the following: a maximally exposed individual, a collective population, U.S. Environmental Protection Agency (EPA), National Emission Standards for Hazardous Air Pollutants (NESHAPs) critical receptors, and the radiation dose to native aquatic organisms. The exposure conditions used in the dose calculations are further discussed in respective environmental monitoring sections of this report.

4.1 Pathway Analysis

In order to develop the specific elements of the environmental monitoring program at the Weldon Spring site, the potential exposure pathways and health effects of the radioactive and chemical materials present at the site and the quarry are reviewed to determine whether the pathways are complete. These analyses of exposure pathways, required by DOE Order 5400.1, are based on the sources, release mechanisms, types, and locations of contaminants; the probable environmental fates of the contaminants; and the locations and activities of potential receptors. Pathways are then reviewed to determine if a link can be shown between one or more contaminant sources, or between one or more environmental transport processes, to an exposure point where human or ecological receptors are present. If it is determined that a link exists the pathway is called complete. Finally, the complete pathways are reviewed and if there was a potential for exposure the pathway is deemed applicable.

Table 4-1 lists the six complete pathways for exposure from contaminants evaluated by the Weldon Spring site environmental monitoring program. These pathways are used to determine radiological and nonradiological exposures from the site. Of the six complete pathways, only four were applicable in 1993 and were thus incorporated into dose estimates. These were Liquid (B), Liquid (C), Airborne (A), and Airborne (B).

TABLE 4-1 Exposure Pathways for the Weldon Spring Site

Exposure Pathway	Pathway Description	Applicable to 1993 Dose Estimate
Liquid(A)	Ingestion of groundwater from local wells downgradient from the site.	N
Liquid(B)	Ingestion of game and fish inhabiting wildlife area.	Y
Liquid(C)	Ingestion of surface water and sediments.	Y
Airborne(A)	Inhalation of particulates dispersed through wind erosion and remedial action.	Y
Airborne(B)	Inhalation of radon emitted from contaminated soils.	Y
External	Direct gamma radiation from contaminated soils.	N

There was no contribution to effective dose equivalents (EDEs) from Pathway Liquid (A) (Table 4-1), ingestion of drinking water from local wells. Currently, concentrations of radioactive contaminants are comparable to background concentrations in the production wells near the Weldon Spring Quarry (see Section 7.4). No drinking water wells are located in the chemical plant/raffinate pits area.

There was no contribution to the effective dose equivalents from the external pathway. Statistical analysis of the results obtained from the external gamma monitoring program indicated that there was no reason to suspect that any of the locations monitored were greater than background levels at the 95% confidence level (see Section 5.2).

The applicable public dose standards or limits for exposure that the Weldon Spring Site Remedial Action Project (WSSRAP) is required to meet are as follows:

- NESHAPs standard of 10 mrem (0.10 mSv) annually for airborne emissions other than radon at critical receptor locations.
- DOE guideline of 100 mrem (1 mSv) annual effective dose equivalent for all exposure pathways on an annual basis.

4.2 Radiological Release Estimates

Radiological release estimates were calculated for airborne particulates, radon gas, and surface water releases. Table 4-2 shows the estimated activity release to the environment and the half-life for each radionuclide. The dashes in Table 4-2 indicate that the amount of radioactivity released to the environment was not distinguishable from background levels. It should be noted, however, that above-background radon gas concentrations were observed at six locations at the quarry (see Section 5.1).

Airborne particulate release estimates were calculated based on NESHAPs monitoring results at two critical receptors located at the chemical plant perimeter. The NESHAPs results indicated that the only detectable above background radiological contaminant was total uranium. The isotopic release estimates in Table 4-2 assume a natural uranium isotopic activity ratio (49.1% U-234, 2.3% U-235, and 48.6% U-238). These emissions were attributed to building dismantlement activities that occurred during 1993. These activities included the dismantlement and demolition of three process buildings and 10 process support buildings, as well as the partial dismantlement of two process buildings and 13 process support buildings. A box model was used to predict the airborne particulate release rate from the chemical plant. The calculations used to estimate airborne releases are shown in Appendix B. In 1993, the estimated U-238, U-234, and U-235 releases were 5.14E-04 Ci, 2.40E-05 Ci, and 5.19E-04 Ci, respectively.

The average radon concentration at the quarry area perimeter was 0.4 pCi/l above background. A box model was used to predict the radon release rate from the quarry for the year. This model assumes that airborne contaminants are dispersed homogeneously within the modeled volume of air. In 1993, the estimated Rn-222 release was 12.5 Ci (4.6×10^{11} Bq). Calculations and assumptions are provided in Appendix B.

During 1993, intermittent surface water runoff was found to have transported uranium from the site through five major discharge routes. These routes were monitored through monthly sampling of the runoff water, as required under the site National Pollutant Discharge Elimination System (NPDES) permit (see Section 6.4). Using NPDES natural uranium values in conjunction with the activity ratios listed above, the U-234, U-235, and U-238 releases to water have been calculated and are presented in Table 4-2. Other radionuclides were not routinely monitored in surface water during 1993.

TABLE 4-2 Radionuclide Emissions to the Environment

Radionuclide	Activity of Radionuclide Released to Air (Ci)	Activity of Radionuclide Released to Water (Ci)	Mass of Radionuclide Released (grams)	Half-Life (Yrs)
U-238	5.14E-04	0.086	258,510	3.47E09
U-235	2.40E-05	0.004	1,885	7.04E08
U-234	5.19E-04	0.087	14	2.34E05
Th-232	--	NA	NA	1.40E10
Th-230	--	NA	NA	7.40E04
Th-228	--	NA	NA	1.910
Ra-228	--	NA	NA	5.76
Ra-226	--	NA	NA	1,600
Rn-222	12.5	NA	NA	3.82 days
Total Activity	12.5	0.177[a]	260,409	NA

NA Not analyzed for this radionuclide
[a] Total uranium value obtained from Table 6-4
-- Not distinguishable from background
Multiply by 3.7E10 to convert Ci to Bq

4.3 Exposure Scenarios

Dose calculations were performed for the maximally exposed individual, collective population, and critical receptors for applicable exposure pathways (Table 4-1) to assess dose from the Weldon Spring site. First, conditions were set to determine dose to a maximally exposed individual at each of the main site areas: the chemical plant/raffinate pits, the quarry, and the vicinity properties. A second dose, for a collective population, was calculated for users of the August A. Busch Memorial Conservation Area. A third set of dose calculations was performed to meet NESHAPs monitoring data. Results of these estimates were then compared to applicable standards to ensure the safety of members of the public and the environment.

A gamma dose was not calculated for the total population within an 80 km (49.6 mi) radius of the site, as recommended in DOE Order 5400.5, because extensive monitoring at the site perimeters indicated no above background external gamma exposure resulting from WSSRAP activities. This conclusion is based on a statistical analysis of environmental thermoluminescent dosimeter (TLD) results (see Section 5). Although several perimeter low volume particulate sampling locations were greater than background, no above-background concentrations were detected through high volume NESHAPs monitoring at off-site locations in the near vicinity of the site. Calculations of collective population doses utilizing perimeter and off-site monitoring data determined the dose to affected populations to be less than 1 person-rem per year (0.01 person Sv) from all pathways. Since all off-site low-volume air particulate samplers and radon gas detectors other than background stations are within a 13 km (8.1 mi) radius, and only the August A. Busch Memorial Conservation Area low volume sampling location yielded above-background concentrations for gross alpha radioactive particulate measurement, incorporating the calculation of a dose for the total population within 80 km (49.6 mi) of the site is unrealistic.

The scenarios and models used to evaluate these radiological exposures were conservative but appropriate. Although radiation doses can be calculated or measured for individuals, it is not appropriate to predict the health risk to a single individual. Estimates of health risks are based on statistical data collected from large groups of people exposed to radiation under various circumstances. Statistical models are not applicable to single individuals. Therefore, dose equivalents to a single individual are estimated by hypothesizing a maximally exposed individual and placing this individual in a reasonable, but very conservative scenario. This is appropriate when the magnitude of the dose to a hypothetical maximally exposed individual is small, as is the case at the WSSRAP. The scenarios and resulting estimated doses used in the calculations are outlined in Table 4-3. In addition, the percentage of the DOE guideline of 100 mrem (1.0 mSv) is provided.

The collective population dose estimate is the product of the effective dose equivalent estimate at the exposure point and the number of persons exposed. Exposure points are locations where members of the public are potentially exposed to airborne radioactive particulate concentrations, radon gas concentrations, external gamma radiation, or radionuclide concentrations in water or food at above-background levels. The effective dose equivalent is calculated by estimating radionuclide concentrations in the air, water, food, and external gamma pathways at a given exposure point. These concentrations and reasonable exposure scenarios are used to estimate the amount of radioactivity ingested or inhaled and the amount of external gamma radiation received by the potentially exposed population.

TABLE 4-3 Exposure Scenarios for Weldon Spring Site Radiological Dose Estimates

Dose Scenario	Pathway	Activity	Media	Exposure Duration	Exposure/ Inhalation/ Ingestion Rate	Concentration	Estimated Dose (person-rem)	Percent of DOE Guidance	Percent of EPA Guidance
WSCP/WSRP Hypothetical Individual	Liquid(B)	Fishing at Busch Lake 36	Fish	365 days	6.5 grams/day	0.017 pCi/g	0.006	0.006%	N/A
	Liquid(C)	Swimming at Busch Lake 36	Sediments	11.25 hours/ year	200 mg/day	110 pCi/g	0.003	.003%	N/A
			Water	11.25 hours/ year	0.05 liters/hour	130 pCi/l	0.02	0.02%	N/A
	Airborne(A)	Visiting Busch Lakes Area	Air	132 hour	0.96 m^3/hour	2.2E-16 μCi/ml	3.69E-6	3.69E-6%	3.69E-5%
	Airborne(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WSQ Hypothetical Individual	Liquid(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Liquid(C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Airborne(A)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Airborne(B)	Walking Near WSQ Perimeter	Air	50 hours/year	1.25 m^3/hour	1.3 pCi/l	1.9	1.9%	N/A
WSVP Hypothetical Individual	Liquid(B)	Fishing at Slough	Fish	N/A	6.5 gms/day	0.002 pCi/g	0.0013	0.0013	N/A
	Liquid(C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	External	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Airborne(A)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Airborne(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 4-3 Exposure Scenarios for Weldon Spring Site Radiological Dose Estimates (Continued)

Dose Scenario	Pathway	Activity	Media	Exposure Duration	Exposure/ Inhalation/ Ingestion Rate	Concentration	Estimated Dose (person-rem)	Percent of DOE Guidance	Percent of EPA Guidance
Collective Population	Liquid(A)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Liquid(B)	Fishing at Busch Lake 36 population = 5985	Fish	N/A	200 g/person	0.017 pCi/g	0.1 person-rem	N/A	N/A
	Liquid(C)	Swimming at Busch Lake 36 (population = 5985)	Sediments	1.125 hours/person	200 mg/day	130 pCi/g	0.0017 person-rem	N/A	N/A
			Water	1.125 hours/person	0.05 liters/hour	110 pCi/g	0.015 person-rem	N/A	N/A
	Airborne(A)	Fishing at Busch Conservation Area	Air	3.5/45	0.95 m^3/hour	2.2E-16 μCi/ml	1.56E-5 person-rem	N/A	N/A
	Airborne(B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

NA Indicates measurements for radioactivity for a media/exposure pathway at background levels.
WSCP Weldon Spring Chemical Plant
WSRP Weldon Spring Raffinate Pits
WSQ Weldon Spring Quarry
WSVP Weldon Spring Vicinity Properties
Multiply by 0.037 to convert pCi to Bq
Multiply by 0.01 to convert mrem to mSv
Multiply by 0.01 to convert person-rem to person-Sv

The NESHAPs committed effective dose equivalent (CEDE) estimate is based on the isotopic analysis of the high volume samples collected from critical receptor locations. The dose estimates are required to demonstrate compliance with the NESHAPs annual exposure limit of 10 mrem.

All ingestion and inhalation calculations were performed using the methodology described in *International Commission on Radiation Protection* (ICRP) Reports 26 and 30 (Ref. 22 and 23) for a 50-year committed effective dose equivalent. Fifty-year committed effective dose equivalent conversion factors were obtained from the EPA *Federal Guidance Report* No. 11 (Ref. 24).

4.4 Dose Estimates

Dose estimates for the exposure scenarios are presented in Table 4-3 and were calculated utilizing 1993 monitoring data. Calculations for dose scenarios are provided in Appendix B. Dose estimates were far below the guidelines set by the DOE for annual public exposure and EPA NESHAPs limits.

The effective dose equivalents to the hypothetical maximally exposed individual near the chemical plant - raffinate pits, quarry, and vicinity properties are <1 mrem (<0.01 mSv), 1.9 mrem (0.019 mSv), and <1 mrem (<0.01 mSv), respectively. This value represents 1.9% of the DOE guideline of 100 mrem (1 mSv) above background for all exposure pathways. For comparison, the annual average exposure to natural background radiation in the area of the site results in a CEDE of approximately 300 mrem (3 mSv). The collective population dose was 0.12 person-rem (0.0012 person-Sv) for recreational users at the Busch Memorial Conservation Area.

The maximum calculated dose for NESHAPs critical receptors was 0.31 ± 0.15 mrem (0.0031 mSv) CEDE at AP-2005 for an individual working in the WSSRAP administration building 2500 hours/year (technically, this individual would not be a member of the public, since the area is under DOE control, but is hypothetically treated as such).

4.4.1 Radiation Dose From the Chemical Plant/Raffinate Pits to a Hypothetical Maximally Exposed Individual

This section discusses the estimated CEDE to a hypothetical individual assumed to frequent the perimeter of the chemical plant/raffinate pits and to receive a radiation dose by the three pathways identified above. No private residences are adjacent to the site. Therefore, all calculations of dose equivalent due to direct gamma exposure, airborne radioactive particulate inhalation, and radon progeny inhalation assume realistic residence times that are less than 100%. Recreational use of the Busch Memorial Conservation Area is considered in the assessment of the exposure to a maximally exposed individual at the chemical plant/raffinate pits area, since some of the lakes in the area receive effluent from the site. None of these lakes are used as sources of drinking water, but recreational use of the conservation area includes fishing and boating. Thus, the Liquid (B) pathway, fish ingestion, and the Liquid (C) pathway, incidental water and sediment ingestion, are potential pathways for exposure.

The low volume gross alpha measurements at the northern perimeter of the chemical plant and Busch Memorial Conservation area were found to be statistically different than background at the 95% confidence level using a one-tailed Student's t test. As discussed in Section 5, gross alpha measurements do not provide insight on which radionuclides the measured alpha particles originated from. Early in the fourth quarter of 1993, an additional high volume NESHAPs sampler was installed at the Busch Memorial Conservation Area sampling location. This type of sampling provides a much lower detection level, due to the greatly increased sample volume, and information regarding the contribution of each radioactive contaminant that would originate from the WSSRAP. Fourth quarter results from the high volume sampler at the Busch Memorial Conservation Area did not indicate any above background concentrations of radionuclides originating from the WSSRAP.

At this time, it has not been determined why gross alpha measurements at the Busch Memorial Conservation Area and chemical plant northern perimeter locations were statistically greater than background. However, this is the first year that a new background station has been in use. There are several potential causes for the differences currently under investigation, one of which is possible higher gross alpha concentrations due to the location's near proximity to gravel roads, which results in higher ambient dust concentrations.

Although the high volume sampler located at the Busch Memorial Conservation Area did not indicate any above background concentrations of radionuclides that would have originated from the WSSRAP, a dose estimate was calculated based on the average net concentration above background levels. The dose estimate was performed because it would not be correct to completely dismiss the above-background gross alpha results until the source of the above-background gross alpha concentrations is determined. The dose estimate performed assumes the primary contaminant is uranium, which is the only above background radionuclide detected from the NESHAPs program at stations located at the WSSRAP perimeter.

Although the gross alpha low volume airborne particulate stations at the northern boundary of the chemical plant were also found to be statistically different than background levels, only the results from the Busch location were used in dose estimates because of the low probability of an individual visiting the location on a regular basis. As a result, a dose estimate was made only for the Busch location, which is a more realistic scenario and would result in a higher dose estimate based on realistic exposure times. The scenarios are as follows:

- Assume inhalation dose occurs to maximally exposed individual during fishing and boating trips for a total of 119.5 hours.

- Assume net airborne particulate concentrations of 2.2E-16 μCi/ml (8.14E-12 Bq/ml) measured at AP-4007 near Busch headquarters buildings.

- The average fresh-water fish consumption rate was 6.5 g/day (0.23 oz/day) (Ref. 25 and 23) and assumed 25 trips averaging 2.5 hour/trip.

- The average U-238 concentration in fish was 0.009 pCi/g (0.0003 Bq/g), collected from Busch Lake 36, where the concentration was the highest of the three lakes receiving runoff from the site (see Section 8.3.1.1).

- An individual made 10 trips per year to the Busch Memorial Conservation Area.

- The individual spent 5.7 hour boating per visit (Ref. 26).

- While boating, the individual spent 25% of the time swimming.

- While swimming the individual ingested 0.05 liters/hour (0.05 qt/hour) of water (Ref. 25 and 26).

- The concentration of uranium in surface water was 4,767 Bq/m^3 (130 pCi/l) from Busch Lake 36 (see Section 6), which had the highest average surface water concentration of the three lakes receiving runoff.

- The average uranium concentration of surface sediments was 110 pCi/g (1.1 Bq/g) from Busch Lake 34, which had the highest concentration.

Based on the exposure scenario and assumptions described above, a maximally exposed individual who frequented areas receiving surface water runoff from the chemical plant perimeter received a total effective dose equivalent of 0.03 mrem (0.0003 mSv) from inhalation of airborne particulate, ingestion of water and sediment, and ingestion of fish from contaminated waters.

4.4.2 Radiation Dose From the Weldon Spring Quarry to a Hypothetical Maximally Exposed Individual

This section discusses the estimated CEDE to a hypothetical individual assumed to frequent the perimeter of the Weldon Spring Quarry. No private residences are adjacent to the quarry site; therefore, all calculations of radon progeny inhalation (Airborne B) assume a realistic residence time of less than 100%. The scenario is based on a hypothetical individual who routinely walked along the northern boundary of the quarry on State Route 94. This scenario is currently being reviewed to reflect a more realistic estimate of visit frequency and duration during 1994.

Scenarios and assumptions particular to this dose calculation are summarized as follows:

- No contribution from pathways Liquid(B) or Liquid(C) of Table 4-1 was determined because access to the quarry was controlled by 24 hour security and a 2.4 m (8 ft) chain link fence topped with barbed wire. Fishing, swimming, and drinking water from the quarry pond were not realistic exposure pathways.

- The individual walked along State Route 94 twice per day, 250 days/year.

- The average residence time near the quarry was 6 minute/trip (Ref. 6).

- The highest measured annual average concentration of radon gas was 1.3 pCi/l (44.4 Bq/m^3) above normal background (0.1 pCi/l) at station RD-1002 of the quarry perimeter (see Section 5).

- The equilibrium ratio between radon gas and its progeny was 50%.

- The effective dose equivalent conversion factor was 1.0 rem/working level month (WLM) (10 mSv/WLM) (Ref. 27).

The dose to the hypothetical maximally exposed individual at the quarry was 1.9 mrem (0.019 mSv) from inhalation of radon daughters.

4.4.3 Radiation Dose From Vicinity Properties to a Hypothetical Maximally Exposed Individual

This section discusses the estimated effective dose equivalent to a hypothetical individual assumed to frequent the Femme Osage Slough, south of the quarry. This scenario provides a conservative but plausible exposure assessment. No private residences are adjacent to the slough (it is situated on land currently managed by the Missouri Department of Conservation (MDC) as part of the Weldon Spring Conservation Area); therefore, all direct gamma exposure calculations assume a realistic less than 100% residence time. This scenario utilizes the exposure pathways and is based on a hypothetical individual who fished at the Femme Osage Slough.

Scenarios and assumptions particular to this dose calculation are summarized as follows:

- No contribution to the estimated dose was included from radon progeny concentrations, Airborne (B), because the slough is contaminated only with uranium and the slough is covered with water. Consequently, above-background concentrations of radon are not expected at this location.

- The average U-234, U-235, and U-238 concentration in fish samples taken from the Femme Osage Slough was 0.002 pCi/g, (see Section 8.3.1.1).

- The fresh water fish consumption rate was 6.5 grams/day (0.23 oz/day) (Ref. 28).

- No contribution from pathway Liquid (C) was included, because the stagnant water conditions made it unlikely that the slough would be used for recreational swimming.

The dose to the maximally exposed individual at the vicinity property from consumption of fish tissue as discussed above was 0.001 mrem (0.00001 mSv) committed effective dose equivalent.

4.4.4 Collective Population Dose

This section discusses the estimated collective CEDE to the populations assumed to frequent the Katy Trail located south of the quarry, and at the Busch Memorial Conservation Area. This scenario provides a conservative but plausible exposure assessment. Since the results from all critical receptor monitoring locations were not significantly different from background concentrations at the 95% confidence level, no collective effective dose equivalent estimate was made for populations at or beyond the critical receptor locations. In addition, statistical analyses of the radon and external gamma measurements made near the quarry along the Katy Trail indicated that there was no reason to suspect at the 95% confidence level that the results were greater than background levels. As a result, no collective effective dose was calculated for the population on the Katy Trail. The scenario used for the Busch Memorial Conservation Area is based on recreational use for fishing and boating activities.

Scenarios and assumptions particular to this dose calculation are summarized as follows:

- No contribution from radon and its progeny was included in the Katy Trail estimate. Results from the measurements near the trail indicated that there was no reason to suspect at the 95% confidence level that results were greater than background levels.

- The MDC estimates that approximately 160,000 persons per year use the Busch Memorial Conservation Area, which is adjacent to the chemical plant/raffinate pits area, while another 5,895 persons participate in recreational boating activities. Busch Lakes 34, 35, and 36 receive runoff from the chemical plant/raffinate pits site, and all three lakes are utilized for fishing and boating purposes. Therefore, a population of 165,895 persons was assumed to have potential for exposure through ingestion of fish, water, and sediment from these lakes.

- If each fish is consumed by a different person, the affected population would be 112,000 persons.
- The highest average U-238 concentration in the fish collected from Lakes 34, 35, and 36 was 0.009 pCi/g (0.00009 Bq/g) (Section 8.3.1.1).
- The average time spent at the Busch Conservation Area per boating trip was approximately 4.5 hours.
- The average time per fishing trip was 3.5 hours.
- Each of 5,895 visitors made only one visit to the area and spent 25% of the time swimming.
- Maximum water concentrations were 130 pCi/l (6.3 Bq/l) (Section 6) and sediment concentrations were 110 pCi/g (4.1 Bq/g) (Ref. 29).

The estimated population dose for the Busch lakes ingestion scenario were 1.56E-5 person-rem (1.56E-7 person-Sv) for inhalation, 0.1 person-rem (0.001 person-Sv) for fish, 0.015 person-rem (0.00015 person-SV) for water, and 0.0017 person-rem (0.000017 person-SV) for sediment. Consequently, the collective population dose estimate for all applicable scenarios for the Busch Memorial Conservation Area exposure point was 0.12 person-rem (0.0012 person-Sv). This dose is considered insignificant as compared to the dose received from natural background sources.

4.5 NESHAPs Release Estimates

In 1990, the WSSRAP initiated an environmental airborne particulate monitoring program sensitive enough to detect airborne radionuclide concentrations at the levels specified in the NESHAPs (40 CFR 61 Subpart H, Appendix E). This regulation requires that radionuclide emissions other than radon be identified and that effective dose equivalents to members of the public be calculated using EPA approved procedures and computer models, or other procedures for which the EPA has granted prior approval. The WSSRAP has chosen to meet these requirements by measuring airborne radionuclide concentrations at designated critical receptor locations rather than using computer modeling. The WSSRAP monitoring plan is contained in the *Plan For Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors* (Ref. 21) which has been approved by EPA Region VII.

Potential airborne emissions at the site result from wind dispersal of surface soils and fugitive dust generated during remedial actions. The most accurate method of dose estimation at critical receptor locations near the site is to measure airborne concentrations at these locations. Critical receptors are locations where members of the public abide or reside and have a potential to encounter off-site concentrations of radionuclides other than radon during remediation of the Weldon Spring site.

Five critical receptor locations have been identified around the site. The common boundary of the chemical plant and the Missouri Highway Maintenance Facility (AP-2001), the WSSRAP administration building (AP-2005), Francis Howell High School (AP-4006), the Weldon Spring Training Area on the Department of the Army property to the southwest (AP-4008), and adjacent to the nearest residence to the quarry (AP-4011). The former background location at AP-4007 was moved to the new background station, AP-4012, in December 1992. A critical receptor monitoring station was installed at the Busch Memorial Conservation Area, AP-4007 during the latter part of 1993. Each station has a high volume air sampler as well as a low volume sampler. The locations of these monitoring stations are shown in Figures 5-1 through 5-4 in Section 5.

An exposure scenario was developed and a dose estimate was calculated for each critical receptor location shown in Table 4-4. Other assumptions used in the dose calculation are:

- Breathing rate of 1.25 m^3/hour (44.1 ft^3/hour) (Ref. 30).
- Fifty-year committed effective dose equivalent conversion factors provided in EPA *Federal Guidance Report No. 11* (Ref. 24).

The results of the NESHAPs dose calculations are presented in Table 4-4. Isotopic air monitoring results from high volume samplers provide emission concentrations for use in NESHAPs dose estimates shown in Table 4-5. The high volume data was used for the dose

TABLE 4-4 Exposure Scenarios and NESHAPs Dose Estimates for 1993

Critical Receptor	Sample ID	Total Individuals	Exposure Duration	Estimated Dose Equivalent (mrem)
Missouri Highway Maintenance Facility	AP-2001	9	2,000 hrs/yr	0.021 ± 0.296
WSSRAP administration building	AP-2005	220	2,500 hrs/yr	0.383 ± 0.496
Francis Howell High School - Assessment 1	AP-4006	1800	2,250 hrs/yr	0.0648 ± 0.3340
Francis Howell High School - Assessment 2	AP-4006	1[b]	365 days/yr	-0.1216 ± 0.5851
Busch Memorial Conservation Area[a]	AP-4007	N/A	119.5 hrs	0.0264 ± 0.1089
Weldon Spring Training Area	AP-4008	1[c]	2,000 hrs/yr	-0.055 ± 0.247
Nearest quarry residence	AP-4011	1[d]	365 days/yr	-0.055 ± 0.249

(a) Based on one quarter of data.
(b) One individual residing full-time on school properties.
(c) One employee working full-time on Army property.
(d) One individual living at residence.
Multiply by 0.01 to convert mrem to mSv

TABLE 4-5 NESHAPs Isotopic Air Monitoring Results Effective Dose Equivalent Contributions, 1993

AP-2001	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	1.27E-10±0	0.0073±N/A	1.80E-10±N/A	0.0104±N/A	1.77E-10±N/A	0.0102±N/A	3.07E-10±N/A	0.0177±N/A	0.0458±N/A
RA-226	-4.64E-12±3.97E-11	0.0000±0.0001	9.85E-12±6.69E-11	0.0000±0.0003	-1.66E-11±8.25E-11	-0.0001±0.0003	-4.41E-12±1.95E-11	0.0000±0.0001	-0.0001±0.0005
RA-228	-4.36E-11±2.71E-10	-0.0001±0.0003	1.05E-10±1.52E-10	0.0002±0.0003	-7.75E-11±1.97E-10	-0.0002±0.0005	-5.50E-11±2.06E-10	-0.0001±0.0005	-0.0002±0.0008
TH-228	-4.93E-11±1.72E-10	-0.0081±0.0142	1.66E-11±6.74E11	0.0027±0.0111	-1.73E-11±7.09E-11	-0.0028±0.0116	-1.74E-11±1.12E-10	-0.0029±0.0184	-0.0111±0.0282
TH-230	-3.00E-11±2.30E-10	-0.0047±0.0180	2.88E-11±8.11E-11	0.0045±0.0127	1.02E-10±8.82E-11	0.0160±0.0138	-4.05E-11±1.01E-10	-0.0063±0.0158	0.0095±0.0304
TH-232	-1.84E-11±2.00E-10	-0.0153±0.0765	-1.07E-12±6.62E-11	-0.0008±0.0521	3.83E-12±7.86E-11	0.0030±0.0618	-1.28E-11±1.10E-10	-0.0100±0.0.862	-0.0232±0.1419
EDE		-0.0209±0.0818		0.0171±0.0547		0.0261±0.0644		-0.0017±0.0895	0.0206±0.1476

AP-2005	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m^3)	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	1.01E-09±N/A	0.0584±N/A	6.69E-10±N/A	0.0386±N/A	1.23E-09±N/A	0.0707±N/A	2.44E-09±N/A	0.1405±N/A	0.3082±N/A
RA-226	-8.09E-12±1.84E-11	0.0000±0.0001	8.34E-11±7.40E-11	0.0003±0.0003	8.63E-12±8.85E-11	0.0000±0.0004	-7.36E-12±1.85E-11	0.0000±0.0001	0.0003±0.0005
RA-228	-7.43E-11±1.34E-10	-0.0002±0.0003	2.17E-10±1.91E-10	0.0006±0.0004	-3.44E-11±2.01E-10	-0.0001±0.0005	2.24E-11±2.14E-10	0.0001±0.0006	0.0004±0.0011
TH-228	-4.48E-12±1.13E-10	-0.0009±0.0186	1.25E-11±6.26E-11	0.0026±0.0103	-8.38E-12±7.17E-11	-0.0017±0.0118	-2.74E-11±1.12E-10	-0.0056±0.0184	-0.0057±0.0301
TH-230	8.67E-11±1.33E-10	0.0169±0.0208	9.87E-11±9.14E-11	0.0193±0.0143	-2.20E-11±7.54E-11	-0.0043±0.0118	-6.68E-11±9.91E-11	-0.0131±0.0155	0.0189±0.0388
TH-232	1.43E-11±1.12E-10	0.0140±0.0882	-6.19E-12±5.70E-11	-0.0061±0.0449	-1.17E-11±7.66E-11	-0.0115±0.0602	-1.28E-11±1.12E-10	-0.0126±0.0884	-0.0162±0.1821
EDE		0.0882±0.0925		0.0552±0.0482		0.0531±0.0624		0.1094±0.0916	0.3058±0.1803

052494

TABLE 4-5 NESHAPs Isotopic Air Monitoring Results Effective Dose Equivalent Contributions, 1993 (Continued)

AP-4006	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	1.65E-11±N/A	0.0010±N/A	6.73E-11±N/A	0.0044±N/A	5.16E-11±N/A	0.0033±N/A	2.90E-12±N/A	0.0002±N/A	0.0081±N/A
RA-226	-5.06E-12±1.91E-14	0.0000±0.0001	1.07E-11±6.70E-11	0.0000±0.0003	3.31E-11±9.25E-11	0.0002±0.0004	-5.16E-12±1.85E-11	0.0000±0.0001	0.0001±0.0022
RA-228	-6.19E-11±1.34E-10	-0.0002±0.0003	9.26E-11±1.66E-10	-0.0002±0.0004	1.06E-10±2.09E-10	0.0003±0.0005	-4.18E-11±2.04E-10	-0.0001±0.0005	0.0003±0.0036
TH-228	-3.95E-11±6.05E-11	-0.0073±0.0149	-4.12E-12±6.10E-11	-0.0008±0.0113	2.05E-12±8.56E-11	0.0004±0.0158	-2.72E-11±8.80E-11	-0.0050±0.0164	-0.0141±0.1147
TH-230	-2.24E-11±9.06E-11	-0.0039±0.0159	-1.13E-11±7.91E-11	-0.0020±0.0139	4.67E-11±9.81E-11	0.0082±0.0173	-4.60E-11±7.93E-11	-0.0069±0.0744	-0.0046±0.1183
TH-232	-1.16E-11±7.89E-11	-0.0102±0.0698	-8.57E-12±6.74E-11	-0.0076±0.0597	3.06E-12±9.32E-11	0.0027±0.0825	-7.79E-12±8.41E-11	-0.0069±0.0744	-0.0245±0.5612
EDE		-0.0207±0.1625		-0.0067±0.0623		0.0151±0.0857		-0.0200±0.0775	-0.0312±0.1503

AP-4007	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	2.18E-11±N/A	0.0013±N/A	0.0013±N/A
RA-226	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	-1.04E-12±2.20E-11	0.0000±0.0001	0.0000±0.0001
RA-228	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	1.95E-10±2.58E-10	0.0006±0.0006	0.0006±0.0007
TH-228	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	1.77E-11±1.13E-10	0.0036±0.0186	0.0036±.0232
Th-230	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	-9.05E-12±1.04E-10	-0.0018±0.0163	-0.0018±0.0204
Th-232	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	N/A±N/A	2.31E-11±1.06E-10	0.0227±0.0836	0.02270±.1044
EDE	N/A±-N/A		N/A±-N/A		N/A±-N/A			0.0264±0.1089	0.0264±0.1089

TABLE 4-5 NESHAPs Isotopic Air Monitoring Results Effective Dose Equivalent Contributions, 1993 (Continued)

AP-4008	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	5.71E-11 ± N/A	0.0033 ± N/A	-9.67E-11 ± N/A	-0.0056 ± N/A	-1.71E-10 ± N/A	-0.0098 ± N/A	1.14E11 ± N/A	0.0007 ± N/A	-0.0115 ± N/A
RA-226	-5.83E-12 ± 1.98E-11	0.0000 ± 0.0001	-9.32E-11 ± 6.09E-11	-0.0004 ± 0.0003	-2.95E-11 ± 6.22E-11	-0.0001 ± 0.0003	-6.60E-12 ± 1.85E-11	0.0000 ± 0.0001	-0.0006 ± 0.0004
RA-228	-6.12E-11 ± 1.37E-10	-0.0001 ± 0.0003	7.91E-11 ± 1.72E-10	0.0002 ± 0.0004	-1.11E-10 ± 1.46E-10	-0.0003 ± 0.0003	2.61E-11 ± 2.04E-10	0.0001 ± 0.0005	-0.0002 ± 0.0008
TH-228	-4.98E-11 ± 8.18E-11	-0.0082 ± 0.0134	-4.01E-12 ± 5.37E-11	-0.0007 ± 0.0088	-2.75E-11 ± 5.58E-11	-0.0045 ± 0.0092	-2.69E-11 ± 8.96E-11	-0.0044 ± 0.0147	-0.0178 ± 0.0238
TH-230	8.45E-11 ± 1.06E-10	0.0134 ± 0.0167	-8.13E-11 ± 6.62E-11	-0.0127 ± 0.0103	-8.54E-11 ± 5.86E-11	-0.0134 ± 0.0092	-2.70E-11 ± 8.44E-11	-0.0042 ± 0.0132	-0.0169 ± 0.0254
TH-232	8.62E-12 ± 8.45E-11	0.0066 ± 0.0649	-1.02E-12 ± 5.82E-11	-0.0008 ± 0.0442	-4.76E-11 ± 5.89E-11	-0.0375 ± 0.0463	2.95E-11 ± 9.65E-11	0.0232 ± 0.0759	-0.0084 ± 0.1187
EDE		0.0150 ± 0.0684		-0.0198 ± 0.0463		-0.0656 ± 0.0481		0.0153 ± 0.0785	-0.0553 ± 0.1238

AP-4011	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual
Radionuclide	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Net Concentration (μCi/m³)	Effective Dose Equivalent (mrem)	Effective Dose Equivalent (mrem)
Total U	-3.25E-12 ± N/A	-0.0002 ± N/A	1.33E-10 ± N/A	0.0077 ± N/A	1.18E-11 ± N/A	0.0007 ± N/A	-2.34E-11 ± N/A	-0.0013 ± N/A	0.0068 ± N/A
RA-226	-1.00E-11 ± 1.08E-10	0.0000 ± 0.0004	1.67E-10 ± 7.60E-11	0.0007 ± 0.0003	-2.11E-11 ± 8.32E-11	-0.0001 ± 0.0003	-1.08E-11 ± 1.72E-11	0.0000 ± 0.0001	0.0005 ± 0.0028
RA-228	-2.44E-12 ± 1.12E-11	0.0000 ± 0.0003	1.58E-10 ± 1.78E-10	0.0016 ± 0.0004	1.10E-10 ± 2.11E-10	0.0011 ± 0.0005	-6.06E-11 ± 1.83E-10	-0.0006 ± 0.0004	0.0021 ± 0.0036
TH-228	-3.40E-11 ± 9.25E-11	-0.0244 ± 0.0152	-3.93E-12 ± 6.04E-11	-0.0028 ± 0.0099	3.36E-11 ± 8.43E-11	0.0242 ± 0.0138	-9.51E-12 ± 1.03E-10	-0.0068 ± 0.0170	-0.0099 ± 0.1246
TH-230	-1.20E-11 ± 8.61E-11	-0.0083 ± 0.0136	-2.01E-11 ± 8.00E-11	-0.0140 ± 0.0127	-5.06E-11 ± 7.56E-11	-0.0351 ± 0.0120	-6.15E-13 ± 8.09E-11	-0.0004 ± 0.0142	-0.0579 ± 0.1152
TH-232	-1.93E-11 ± 6.70E-11	-0.0660 ± 0.0439	9.35E-12 ± 6.70E-11	0.0322 ± 0.0527	-3.99E-11 ± 7.62E-11	-0.1376 ± 0.0600	-1.12E-11 ± 9.89E-11	-0.0385 ± 0.0764	-0.2089 ± 0.5179
EDE		-0.0980 ± 0.0483		0.0264 ± 0.0651		-0.1468 ± 0.0627		-0.0477 ± 0.0786	-0.2573 ± 0.5450

TABLE 4-5 NESHAPs Isotopic Air Monitoring Results Effective Dose Equivalent Contributions, 1993 (Continued)

AP-4012	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
Radionuclide	Concentration ($\mu Ci/m^3$)	Concentration ($\mu Ci/m^3$)	Concentration ($\mu Ci/m^3$)	Concentration ($\mu Ci/m^3$)	Effective Dose Equivalent (mrem)
Total U	2.52E-10 ± N/A	2.10E-10 ± N/A	1.86E-10 ± N/A	1.67E-10 ± N/A	-
RA-226	1.46E-11 ± 1.61E-11	1.34E-10 ± 4.46E-11	3.42E-11 ± 6.21E-11	1.41E-11 ± 1.49E-11	-
RA-228	1.37E-10 ± 9.81E-11	1.93E-11 ± 8.37E-11	1.24E-10 ± 1.46E-10	1.17E-10 ± 1.55E-10	-
TH-228	5.27E-11 ± 6.31E-11	7.48E-12 ± 3.27E-11	3.16E-11 ± 5.57E-11	2.74E-11 ± 8.09E-11	-
TH-230	1.25E-10 ± 6.79E-11	9.65E-11 ± 5.05E-11	8.94E-11 ± 5.85E-11	8.24E-11 ± 5.64E-11	-
TH-232	3.07E-11 ± 5.70E-11	1.88E-11 ± 3.70E-11	4.91E-11 ± 5.88E-11	1.28E-11 ± 7.46E-11	-

N/A Not available
\- Background annual dose not calculated
EDE Effective Dose Equivalent

calculation, since the detection limits were more accurate with the larger volume of air sampled. The doses were all less than 0.4 mrem (0.004 mSv) per year at each critical receptor location for both high and low volume results and were similar to the total committed effective dose equivalent calculated for NESHAPs in 1992.

Data quality review of precision and accuracy for the NESHAPs high volume samples indicated that data quality objectives established in the *Plan for Monitoring Radionuclides Other Than Radon at Weldon Spring Critical Receptors* (Ref. 21) were not completely achieved. Although the precision requirements were met, only 50% of the spiked filters met the established criteria. All of the uranium spikes met the established criteria but all of the Th-230 spikes failed. Failure of the Th-230 spikes was found to be caused by a spike preparation problem rather than a laboratory analysis problem.

A careful review of the documentation on spike solution preparation indicated that the solution had not been preserved with nitric acid. Thus, the Th-230 did not remain in solution and could not have been applied to the filters at the concentration expected. Therefore, laboratory analyses were accurate when they indicated activities much less than the spike activities. In addition, the contracted laboratory prepared and analyzed Th-230 matrix spikes, and the results were all well within acceptable ranges.

When a new spike solution was prepared and applied to first quarter 1994 NESHAPs filters, 100% of the spiked filters met data quality objectives. Based on these results, and identification of the source of spike data quality failure, it is possible to conclude that the concentrations measured at the critical receptor locations are valid.

4.6 Radiation Dose to Native Aquatic Organisms

Since benthic invertebrate samples could not be collected during 1993 (see Section 8.3.1.2), the radiation dose to native aquatic organisms was calculated using the highest concentration of uranium detected in benthic invertebrates during 1992. The highest uranium concentration detected was 32 pCi/g in a sample from Frog Pond.

The 1993 dose to native aquatic organisms was therefore calculated in the same manner as for 1992, and was compared to the DOE guideline of 1 rad/day. The absorbed dose rate to these organisms was 0.04 rad/day. Further sampling will be conducted in calendar year 1994 and these calculations will be updated at the completion of these events.

4.7 Highlights

- The effective dose equivalent for the maximally exposed hypothetical individual from all pathways was 1.9 mrem. This value represents 1.9% of the DOE guideline of 100 mrem (1 mSv) above background.

- The NESHAPs standard of 0.10 mSv (10 mrem) annually for airborne emissions was not exceeded in 1993. The committed effective dose equivalents were calculated as <0.4 mrem for each of the critical receptor monitoring locations.

5 RADIATION AND ASBESTOS MONITORING PROGRAM

The Weldon Spring Site Remedial Action Project (WSSRAP) operates its environmental monitoring and surveillance program in accordance with the U.S. Department of Energy (DOE) Orders in the 5400 series and with the *Environmental Monitoring Plan for Calendar Year 1993* (Ref. 9). This section describes monitoring results for radon, external gamma radiation, airborne radioactive particulates and asbestos at various site perimeter and off-site locations. A program overview, summary of applicable standards, actual monitoring results, and an assessment of any associated environmental impacts is provided below for each parameter mentioned in the plan.

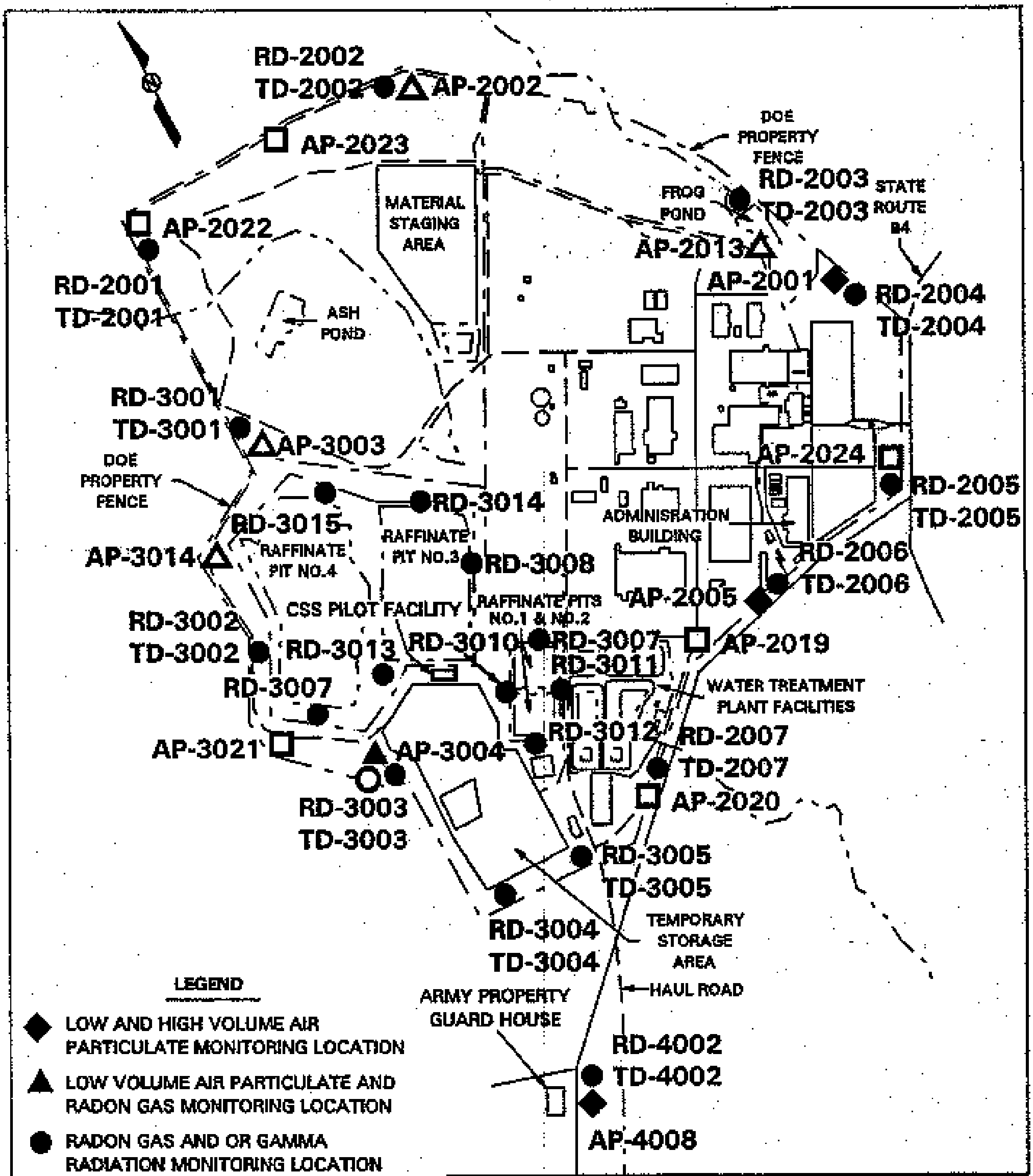
5.1 Radon Gas Monitoring Program

5.1.1 Program Overview

Both U-238 and Th-232 are naturally occurring radionuclides in soil and rock. Radon (Rn-220 and Rn-222) is a naturally occurring radioactive gas found in both the uranium and thorium decay series. A fraction of the radon produced from the radioactive decay of naturally occurring U-238 and Th-232 diffuses from soil and rock into the atmosphere, accounting for natural background airborne radon concentrations. Radon is produced at the Weldon Spring site from these natural sources as well as from the contaminated waste materials present at the site.

Airborne radon concentrations fluctuate with both soil conditions and meteorological conditions. The amount of radon that actually enters the atmosphere varies depending on a number of parameters, including radium concentrations in soil, soil moisture content, soil porosity, soil density, and atmospheric pressure. Of these, the moisture content of the soil is the most variable and is primarily responsible for quarterly and annual changes in airborne radon concentrations.

The environmental radon monitoring program utilizes a pair of radon detectors at each of the 37 permanent monitoring locations; seven at the Weldon Spring Chemical Plant (WSCP) perimeter, eight at the Weldon Spring Quarry (WSQ) perimeter, 13 at the raffinate pits area, and nine at off-site locations. Radon monitoring locations are identified with an "RD" prefix in Figures 5-1, 5-2, 5-3, and 5-4. WSCP and WSQ monitoring locations are distributed around



LEGEND

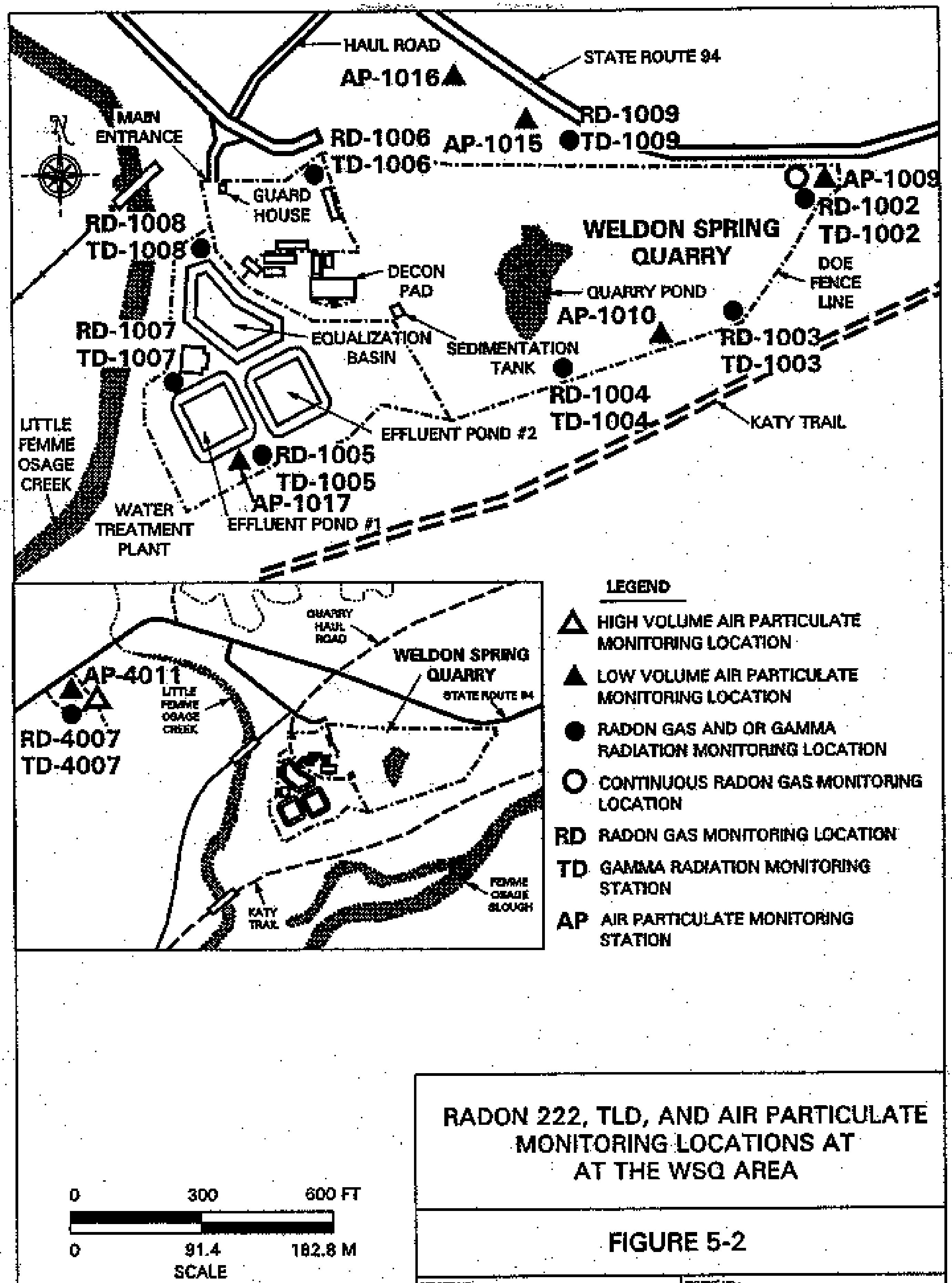
- ◆ LOW AND HIGH VOLUME AIR PARTICULATE MONITORING LOCATION
- ▲ LOW VOLUME AIR PARTICULATE AND RADON GAS MONITORING LOCATION
- ● RADON GAS AND OR GAMMA RADIATION MONITORING LOCATION
- ○ CONTINUOUS RADON GAS MONITORING LOCATION
- △ LOW VOLUME PERMANENT AIR PARTICULATE MONITORING LOCATION
- □ LOW VOLUME PORTABLE AIR PARTICULATE MONITORING LOCATION

0 500 1000 FT
0 152.4 304.8 M
SCALE

RADON-222, TLD, AND AIR PARTICULATE MONITORING LOCATIONS AT THE WSCP/WSRP AREA

FIGURE 5-1

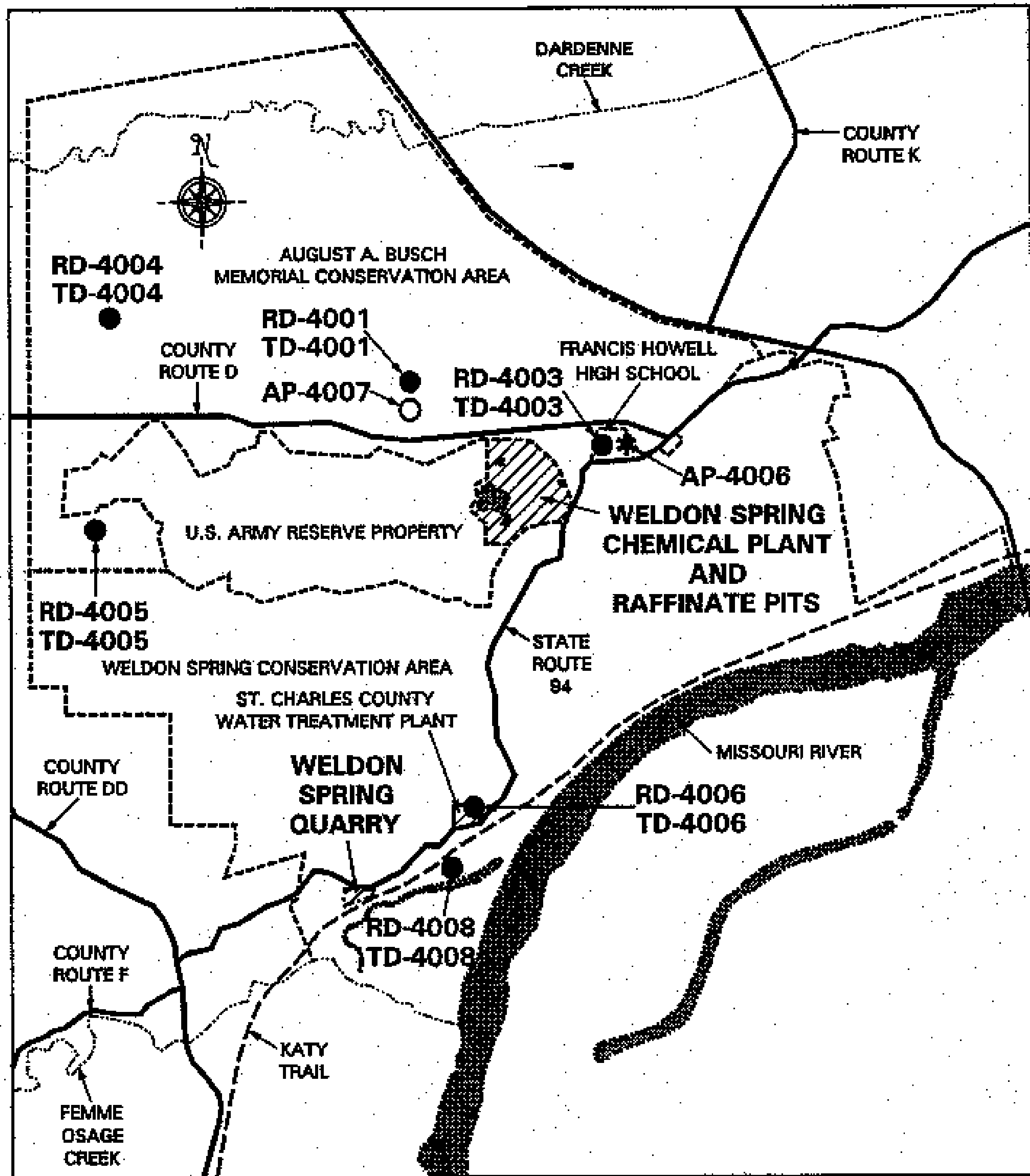
REPORT NO.:	DOE/OR/21548-436	EXHIBIT NO.:	A/CP/010/0294
ORIGINATOR:	MAP	DRAWN BY:	GLN	DATE: 2/25/94



RADON 222, TLD, AND AIR PARTICULATE MONITORING LOCATIONS AT AT THE WSQ AREA

FIGURE 5-2

REPORT NO.: DOE/OR/21548-436		EXHIBIT NO.: A/QY/026/0294	
ORIGINATOR: MAP	DRAWN BY: GLN	DATE: 2/25/94	



LEGEND

- ● - RADON GAS AND GAMMA RADIATION MONITORING LOCATION
- ✱ - LOW AND HIGH VOLUME AIR PARTICULATE AND CONTINUOUS GAS MONITORING LOCATION
- ○ - LOW AND HIGH VOLUME AIR PARTICULATE MONITORING LOCATION

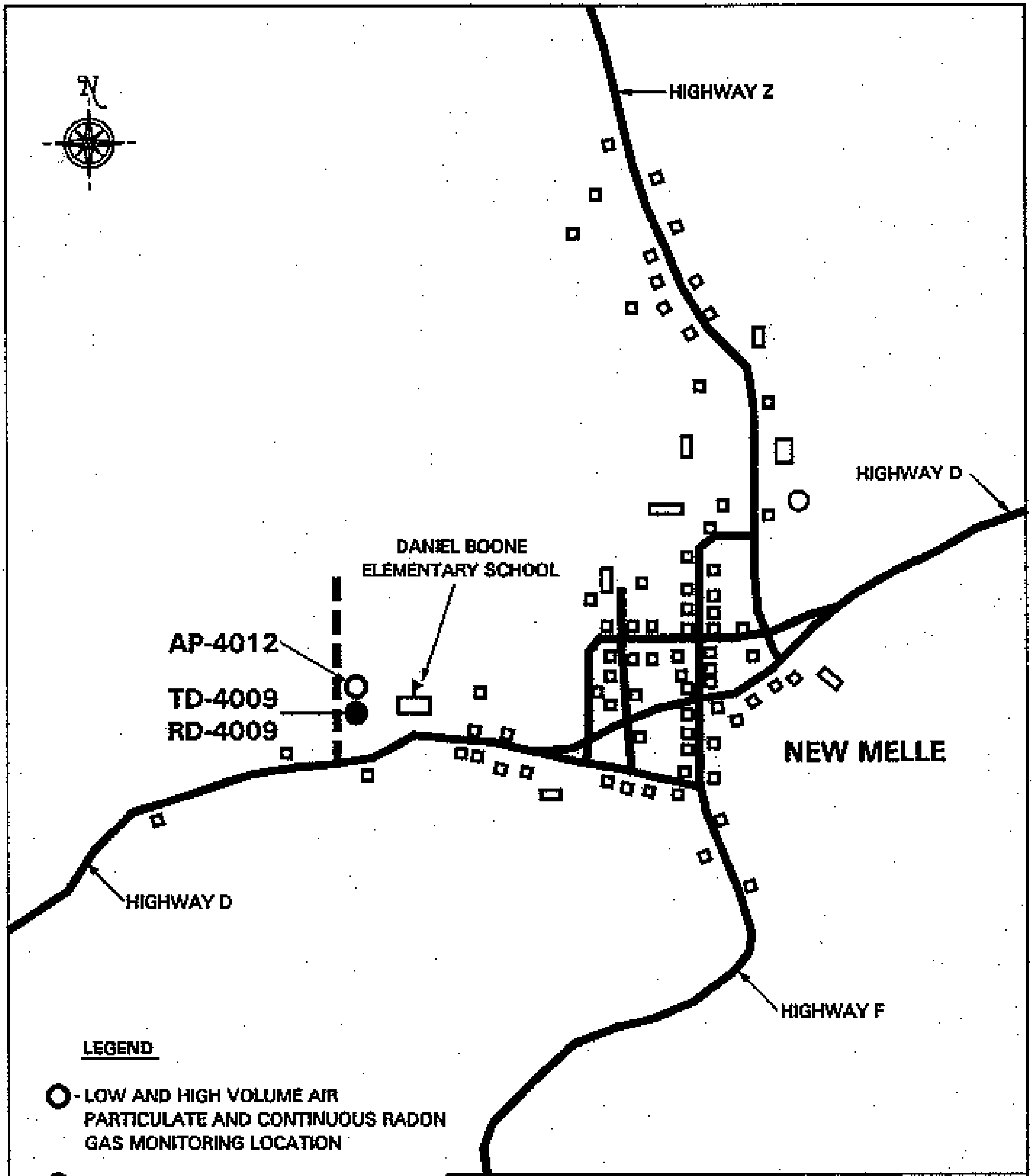
0 1 MI
0 1.6 KM
SCALE

OFF-SITE RADON AND GAMMA RADIATION MONITORING LOCATIONS

FIGURE 5-3

REPORT NO.:	DOE/OR/21548-436	EXHIBIT NO.:	A/VP/002/0294

ORIGINATOR:	MAP	DRAWN BY:	GLN	DATE:	5/3/94



BACKGROUND AIR MONITORING STATION

FIGURE 5-4

REPORT NO.:	DOE/OR/21548-436		EXHIBIT NO.:	A/VP/003/0294	
ORIGINATOR:	MAP	DRAWN BY:	GLN	DATE:	2/22/94

the perimeter to ensure adequate detection of radon dissipating from the site under various atmospheric conditions. Locations RD-4001, RD-4004, RD-4005, RD-4006, and RD-4009 monitor background radon concentrations. The radon detectors used in this program are alpha track detectors that are sensitive to all isotopes of radon and are deployed quarterly.

The radon environmental monitoring program also utilized continuous radon and radon daughter monitors. Continuous radon monitors were placed at locations AP-4012, AP-3004, AP-1009, and AP-4006. The continuous radon daughter monitors were located at AP-1009 and AP-4006, as shown in Figures 5-1, 5-2, and 5-3. The continuous radon monitors were in operation in the beginning of the year, were removed for calibration in early April, and started again in mid-June. The continuous radon daughter monitors were operated January through March. The radon daughter monitors were removed from the environmental monitoring locations and used for worker protection monitoring. The radon daughter monitors are more beneficial for worker protection than the radon monitors, and the radon monitors provide adequate monitoring at the perimeter and off-site locations to perform dose calculations, if necessary. These monitors measure (hourly average) radon concentrations and the data are collected and analyzed at least weekly. The monitors are calibrated once per year at a DOE radon chamber facility.

5.1.2 Applicable Standards

DOE Order 5400.5 specifies a derived concentration guideline (DCG) for unrestricted areas (off-site areas) of 3 pCi/l (111 Bq/m^3), for an annual average, above the background radon concentration.

5.1.3 Monitoring Results

Table 5-1 summarizes quarterly and annual average radon concentrations. Since radon is naturally occurring, each location is compared to the background stations to determine whether any significant differences existed at the 95% confidence level. Locations with levels significantly higher than background were compared to the DCG. For the DCG comparison, the average annual background concentration was subtracted from the annual average concentration before comparison.

TABLE 5-1 1993 Alpha Track Radon Results[a]

Location I.D.	1st Quarter pCi/l	2nd Quarter pCi/l	3rd Quarter pCi/l	4th Quarter pCi/l	Annual Average pCi/l	Annual Standard Deviation	Percent of Guideline (b)
Weldon Spring Quarry							
RD-1002	1.0	1.1	1.3	1.9	1.3	0.38	40
RD-1003	0.6	0.4	0.4	0.6	0.5	0.13	13
RD-1004	0.1	0.2	0.1	0.1	0.1	0.03	-
RD-1005	0.3	0.1	0.1	0.2	0.2	0.06	3
RD-1006	0.3	0.1	0.1	0.2	0.2	0.09	3
RD-1007	0.3	0.2	0.1	0.3	0.2	0.10	3
RD-1008	0.2	0.2	0.1	0.2	0.1	0.03	-
RD-1009	0.3	0.2	0.1	N/A	0.2	0.10	3
Weldon Spring Chemical Plant							
RD-2001	0.1	0.1	0.1	0.2	0.1	0.04	-
RD-2002	0.1	0.1	0.1	0.2	0.1	0.05	-
RD-2003	0.1	0.2	0.1	0.2	0.1	0.06	-
RD-2004	0.2	0.1	0.1	0.1	0.1	0.06	-
RD-2005	0.2	0.1	0.1	0.1	0.1	0.05	-
RD-2006	0.1	0.1	0.1	0.1	0.1	0.04	-
RD-2007	0.2	0.1	0.1	0.1	0.1	0.03	-
Weldon Spring Raffinate Plant							
RD-3001	0.1	0.2	0.1	N/A	0.1	0.06	-
RD-3002	0.1	0.1	0.2	0.1	0.1	0.03	-
RD-3003	0.1	0.1	0.1	0.1	0.1	0.02	-
RD-3004	0.1	0.1	0.1	0.1	0.1	0.01	-
RD-3005	0.1	0.1	0.1	0.1	0.1	0.02	-
RD-3007	0.2	0.2	0.1	0.2	0.2	0.06	3
RD-3008	0.1	0.1	0.1	0.1	0.1	0.03	-
RD-3009	0.1	0.1	0.1	0.1	0.1	0.03	-
RD-3010	0.1	0.2	0.1	0.3	0.2	0.09	3
RD-3011	0.2	0.1	0.1	0.1	0.1	0.03	-
RD-3012	0.2	0.2	0.2	0.3	0.2	0.05	3
RD-3013	0.3	0.1	0.1	0.2	0.2	0.09	3
RD-3014	0.3	0.4	0.5	0.2	0.3	0.11	7
Off Site							
*RD-4001	0.2	0.1	0.1	0.1	0.1	0.04	-
RD-4002	0.1	0.2	0.1	0.1	0.1	0.04	-
RD-4003	0.1	0.1	0.1	0.1	0.1	0.02	-

TABLE 5-1 1993 Alpha Track Radon Results[a] (Continued)

Location I.D.	1st Quarter pCi/l	2nd Quarter pCi/l	3rd Quarter pCi/l	4th Quarter pCi/l	Annual Average pCi/l	Annual Standard Deviation	Percent of Guideline (b)
*RD-4004	0.1	0.1	0.1	0.1	0.1	0.02	-
*RD-4005	0.1	0.1	0.1	0.1	0.1	0.03	-
*RD-4006	0.1	0.1	0.2	0.1	0.1	0.03	-
RD-4007	0.1	0.2	0.1	0.1	0.1	0.04	-
RD-4008	N/A	0.2	N/A	N/A	0.2	N/A	-
*RD-4009	0.1	0.1	0.1	0.1	0.1	0.01	-

(a) Results include natural background levels.
(b) Percent of guideline is calculated by taking the year-to-date average minus the average of the background stations divided by the DOE concentration guideline for Rn-222 of 3 pCi/l (100 Bq/m^3) annual average above background for uncontrolled areas.
* Background station.
N/A Missing track etch detector or a detector that was not deployed, such as previous quarters for new monitoring stations.

The results obtained from the pair of alpha track detectors for each location were averaged to determine the quarterly average radon concentration. These averages were then used to calculate the annual average radon gas concentration. The annual standard deviation reported reflects the error propagated by taking the standard deviation of the mean of the quarterly results.

The annual alpha track background concentration was calculated using the arithmetic average of the five background locations. The data yielded an annual background average radon concentration in 1993 of (0.1 pCi/l (3.7 Bq/m^3). The average background radon concentration did not significantly change from the 1991 and 1992 averages of 0.3 pCi/l (11.1 Bq/m^3) and 0.2 pCi/l (7.4 Bq/m^3) respectively.

Average quarterly radon concentrations were consistent at all locations with the exception of quarry air sampling location AP-1009. During the fourth quarter there was a definite increase in airborne radon concentrations. This increase is a result of quarry bulk waste removal activities and was expected. Disturbance of the soils during bulk waste removal operations allows a much greater radon emanation fraction from the soil interstitial pore spaces to the atmosphere than occurs from undisturbed soil. The elevated results measured during the fourth quarter are expected to continue throughout bulk waste removal.

Table 5-2 summarizes the continuous radon monitor results, shown as quarterly results and annual averages for each monitoring location. The annual averages were also compared to the DCG, after subtracting the background station AP-4012 results, and are shown in the table.

TABLE 5-2 1993 Continuous Radon Monitoring Results[a]

Location ID	1st Quarter (pCi/l)		2nd Quarter (pCi/l)		3rd Quarter (pCi/l)		4th Quarter (pCi/l)		Annual		
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Percent of Guideline (b)
AP-3004	0.61	0.14	0.34	0.08	0.41	0.16	0.37	0.07	0.44	0.16	-
AP-4006	0.49	0.12	0.32	0.06	0.38	0.07	0.45	0.06	0.43	0.10	-
*AP-4012	0.64	0.15	0.35	0.04	0.36	0.09	0.40	0.05	0.46	0.16	-
AP-1009	1.54	1.06	1.06	0.64	1.71	0.47	3.19	1.76	2.06	1.43	53

(a) Results include natural background.
(b) Percent of guideline calculated by taking the year-to-date average minus the average of the background stations divided by the DOE concentration guideline for RN-222 of 3 pCi/l (100 Bq/m^3) annual average above background for uncontrolled areas.
* Denotes background station

Although fourth quarter results at the AP-1009 had a notable increase, it should be noted that the results obtained from the continuous monitors are consistently greater than the results obtained from the alpha track detectors. The continuous monitor results are believed to be biased high. This bias is probably a result of the annual calibration performed at the DOE facility in Grand Junction, CO. The detectors are calibrated at 3 pCi/l (111 Bq/m^3), 10 pCi/l (370 Bq/m^3), and 25 pCi/l (925 Bq/m^3) airborne concentrations. To more closely represent environmental concentrations the possibility of lowering these calibration concentrations is being investigated. In addition, the continuous monitors require significant maintenance and downtime. Maintenance and downtime could have a bias effect on the averaged monitoring results.

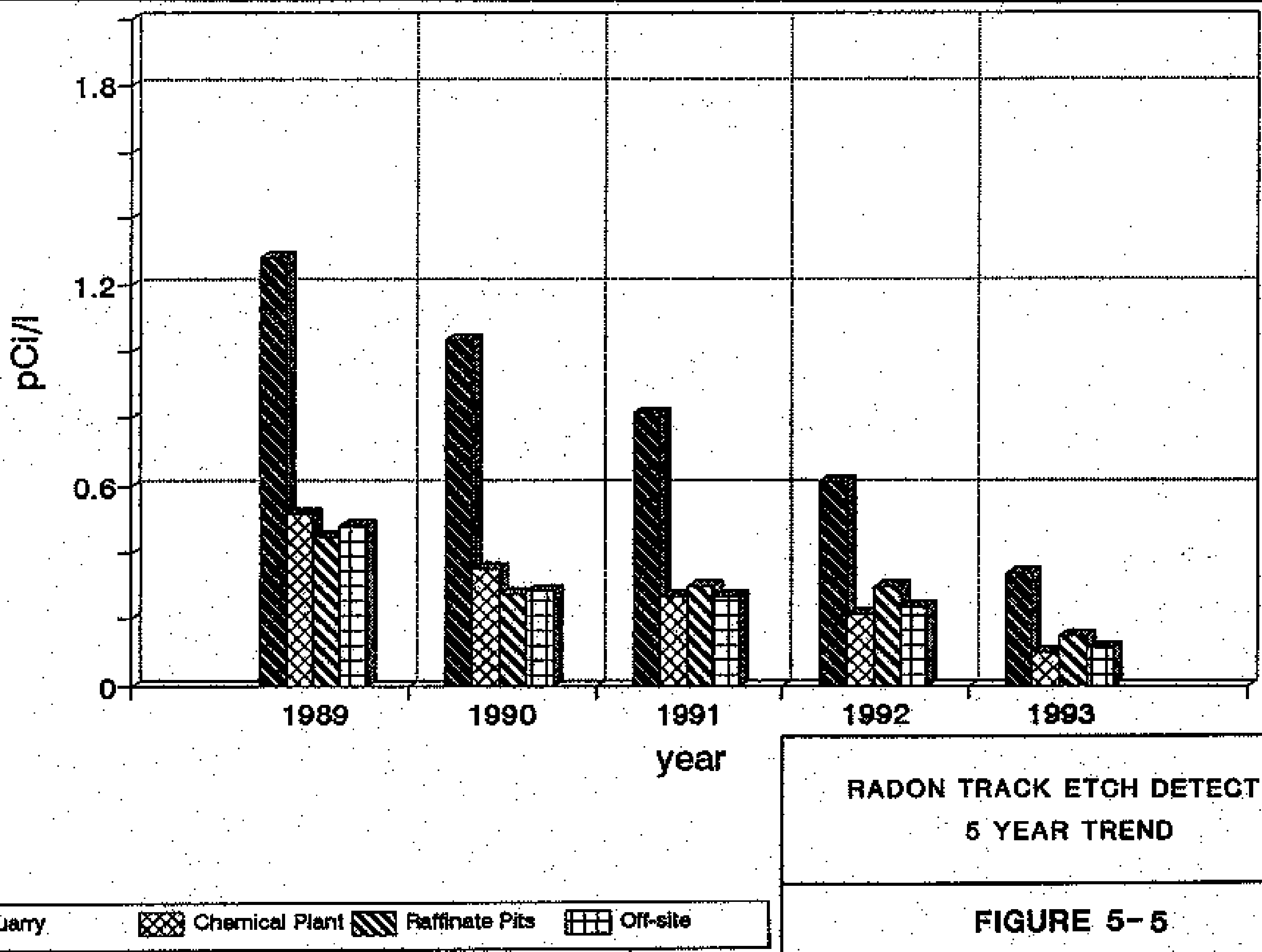
5.1.4 Data Analysis

Statistical analysis of the radon alpha track detector results indicated that at the 95% confidence level, the measured concentrations at five of the eight monitoring locations at the quarry perimeter were greater than the background monitoring location concentrations. In addition, the analysis indicated that measurements from five of the 13 raffinate pit locations were greater than the background station results. The analysis indicates that the results for all other stations are no higher than background levels.

5.1.4.1 Chemical Plant/Raffinate Pits. Statistical analysis of locations RD-3007, RD-3010, RD-3012, RD-3013, and RD-3014 shows measured results higher than background levels. These stations are located around the raffinate pits perimeter. The average concentrations for the above monitoring stations exceeded background levels by 0.1 pCi/l (3.7 Bq/m^3) to 0.2 pCi/l (7.4 Bq/m^3). The statistical test is based largely on averages and standard deviations of the sample groups. When the standard deviations are small, the test detects smaller differences between the two data groups. Because the standard deviations among the quarterly analysis results for these sample locations were small, (the difference between the average concentration was only 0.1 pCi/l [3.7 Bq/m^3]) the hypothesis test was able to conclude that the sampling locations were greater than background levels. Although the failure of these stations may be the result of the potential for 5% false positive conclusions associated with the statistical test at the 95% confidence level, potential impacts were assessed for a hypothetical individual as discussed in Section 4.4.2. The quarterly measured radon concentrations from all stations ranged from 0.1 pCi/l (3.7 Bq/m^3) to 0.5 pCi/l (18.5 Bq/m^3) at the chemical plant/raffinate pits monitoring locations.

5.1.4.2 Quarry. The measured concentrations at the quarry indicated that five of the eight sampling locations were greater than background levels. These results were not unexpected, because the quarry contains significant radium contamination, and quarry bulk waste removal activities began in 1993. Furthermore, the quarry is surrounded by steep walls, and this tends to stagnate the air inside it. This inhibits dispersion and results in an increased concentration at the perimeter of the quarry. The impact of the above background radon concentrations to a hypothetical maximally exposed individual was assessed as described in Section 4.4.2. The quarterly measured results ranged from 0.1 pCi/l (3.7 Bq/m^3) to 1.9 pCi/l (70.3 Bq/m^3).

5.1.4.3 Off Site. Statistical analysis of monitoring results from off-site locations indicated that there was no reason to suspect at the 95% confidence level that measured concentrations at any of the stations were greater than background levels. The quarterly radon concentration measurements at off-site locations ranged from 0.1 pCi/l (3.7 Bq/m^3) to 0.2 pCi/l (7.4 Bq/m^3). These results are similar to results obtained during previous years.



RADON TRACK ETCH DETECTOR
5 YEAR TREND

FIGURE 5-5

REPORT NO.:	DOE/OR/21548-436	EXHIBIT NO.:	A/PI/007/0294

ORIGINATOR:	MAP	DRAWN BY:	GLN	DATE:	2/22/94

5.1.4.4 Five Year Trend Analysis of Radon Gas. Figure 5-5 shows the annual average radon concentration for the monitoring stations at the quarry, chemical plant, raffinate pits, and off-site locations. These monitoring results include natural background radon concentrations. The monitoring results at the quarry seem to indicate a significant downward trend. This trend appears to continue in 1993; however, this is primarily due to the addition of two new stations at the quarry near the water treatment plant. These stations are further away from the contaminated soils than the other stations, and when averaged with existing station results, appear to result in a lower average concentration for the area.

5.2 Gamma Radiation Monitoring

5.2.1 Program Overview

Gamma radiation is emitted from natural, cosmic, and manmade sources. The earth naturally contains gamma radiation emitting substances, such as uranium, thorium, and potassium (K-40). Cosmic radiation originates in outer space and filters through the atmosphere to the earth. Together, these two sources compose natural background radiation. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (Ref. 31) estimates the typical gamma radiation dose is 35 mrem/year from the earth and 30 mrem/year (0.30 mSv/year) from cosmic sources. The total estimated background radiation for this area is 65 mrem/year (0.65 mSv/year).

Gamma radiation is monitored at the site using environmental thermoluminescent dosimeters (TLDs) at 29 monitoring stations: seven at the site perimeter, five near the raffinate pits, eight along the quarry perimeter, and nine off site. The locations are denoted by a "TD" prefix on Figures 5-1, 5-2, 5-3, and 5-4. Stations TD-4001, TD-4004, TD-4005, TD-4006, and TD-4009 measure natural background at locations unaffected by the site. The TLDs are changed every quarter.

5.2.2 Applicable Standards

There is no specific standard for gamma radiation in the DOE orders; however, DOE Order 5400.5 specifies that members of the public shall receive less than 100 mrem/year (1.0 mSv/year) from DOE operations for all exposure pathways.

5.2.3 Monitoring Results

Table 5-3 summarizes quarterly and annual average gamma radiation monitoring results. The table includes quarterly averages, annual totals, and the annual standard deviation for each station. The annual standard deviation reported reflects the error propagated by taking the standard deviation of the mean of the quarterly results.

The background levels of gamma radiation for 1993 were determined by averaging the quarterly measurements from the five background stations. The average rate from these stations was 60 mrem/year (0.60 mSv) with a standard deviation of 8 mrem/year (0.08 mSv). This average background is approximately the same as the UNSCEAR 1992 estimate of 65 mrem/year (0.65 mSv/year).

The first quarter TLD results were significantly higher than TLD results in the remaining quarters. This is because the control TLD monitoring results were significantly higher than expected, and therefore, were not subtracted from the gross TLD results. The cause of these high control TLD results is not known. First quarter TLD results are listed, but are not used in calculating the annual total. To calculate the annual total gamma radiation rate, the missing data, and the first quarter data, were replaced with the average of the remaining quarterly TLD results for those stations.

5.2.4 Data Analysis

Statistical analysis of TLD detector results at the 95% confidence level showed no radiation levels above background. Based on this analysis, there is no reason to believe that above background external gamma exposure to members of the public occurred as a result of WSSRAP activities.

5.2.4.1 Chemical/Raffinate Pits. The annual total gamma radiation measurements from TLDs at the chemical plant and raffinate pits ranged from 60 mrem (0.60 mSv) to 67 mrem (0.67 mSv). These results are comparable from previous years for these areas.

5.2.4.2 Quarry. The annual total gamma radiation measurements from TLDs at the quarry ranged from 59 mrem (0.59 mSv) to 71 mrem (0.71 mSv). These results are comparable from previous years for this areas.

TABLE 5-3 1993 Environmental TLD Results[a]

Location I.D.	1st Quarter (mrem)	2nd Quarter (mrem)	3rd Quarter (mrem)	4th Quarter (mrem)	Annual Total[b] (mrem/yr)	Standard Deviation
Weldon Spring Quarry						
TD-1002	29	18	19	16	71	1
TD-1003	28	17	16	16	65	1
TD-1004	28	17	19	16	69	1
TD-1005	28	17	16	19	69	1
TD-1006	25	16	18	17	68	1
TD-1007	28	18	17	18	71	1
TD-1008	27	16	17	14	63	1
TD-1009	24	17	14	13	59	2
Weldon Spring Chemical Plant						
TD-2001	26	15	16	15	60	0
TD-2002	25	15	16	15	61	1
TD-2003	26	17	16	16	64	1
TD-2004	27	18	15	17	67	1
TD-2005	24	16	15	14	60	1
TD-2006	25	15	17	16	63	1
TD-2007	26	15	16	15	61	1
Weldon Spring Raffinate Pit						
TD-3001	--	15	15	14	59	1
TD-3002	27	12	12	11	47	1
TD-3003	28	16	17	17	67	1
TD-3004	25	13	13	14	53	1
TD-3005	28	16	15	17	64	1
Off Site						
*TD-4001	25	17	14	16	63	1
TD-4002	22	12	11	13	48	1
TD-4003	22	12	11	14	49	1
*TD-4004	27	18	18	--	72	0
*TD-4005	24	14	13	13	53	1
*TD-4006	25	15	16	14	60	1
TD-4007	24	13	14	13	53	1
TD-4008	29	13	--	--	52	-
*TD-4009	25	13	12	14	52	1

* Denotes background location.

(a) Results include natural background gamma radiation.

(b) To calculate the annual total gamma radiation rate, the missing data and the first quarter data were replaced with the average of the remaining quarterly TLD results for those stations.
-- Denotes lost or damage TLD.
To convert to mSv/year, divide by 100.

5.2.4.3 Off-Site. The annual total gamma radiation measurements from TLDs at off-site locations ranged from 48 mrem (0.48 mSv) to 72 mrem (0.72 mSv). These results are comparable from previous years for these areas.

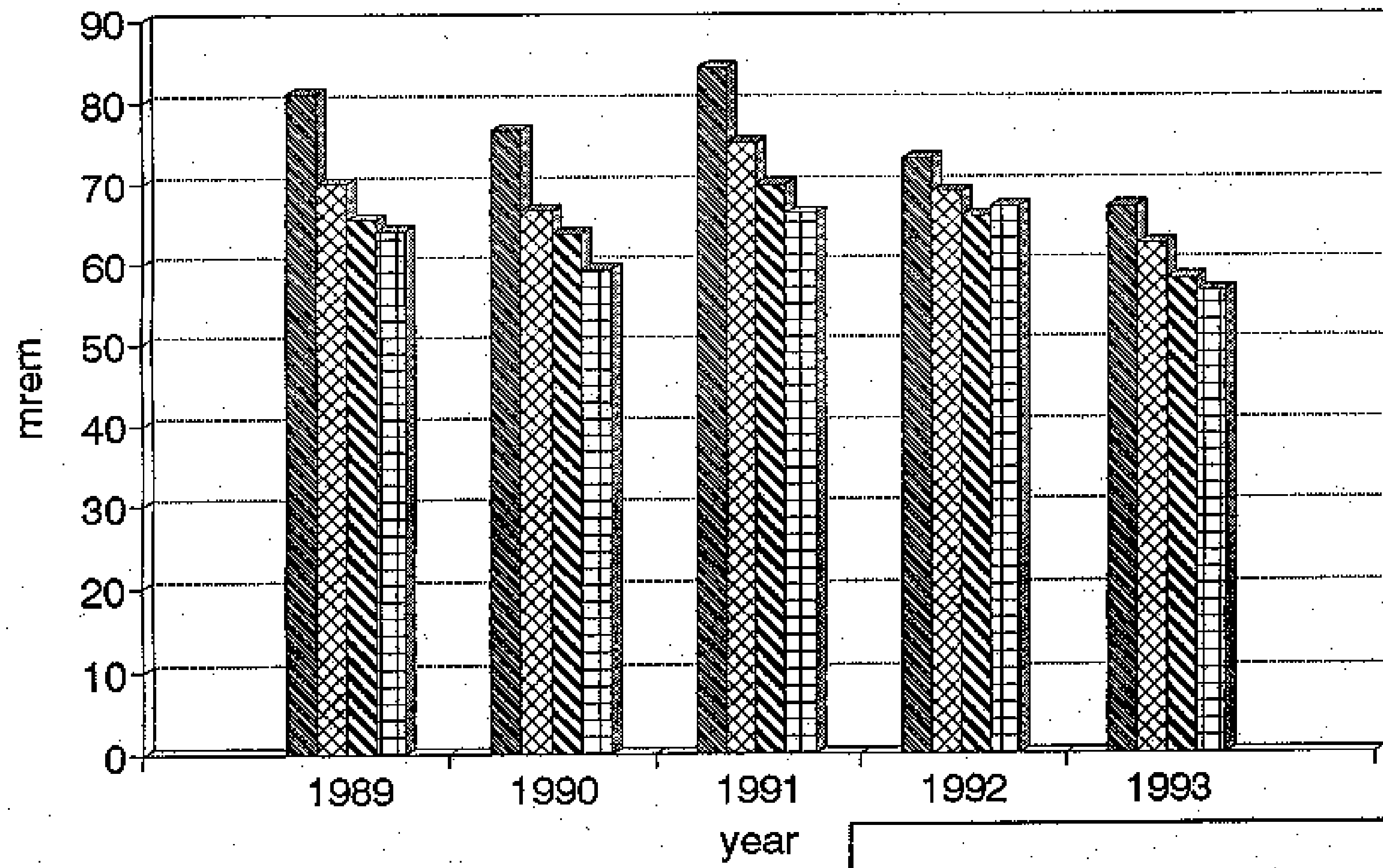
5.2.4.4 Five Year Trend Analysis of TLDs. Gamma radiation exposure monitoring results from the last five years are shown graphically in Figure 5-6. The graph shows yearly monitoring result averages for the chemical plant, raffinate pits, quarry, and off-site locations. The results include the natural background dose rate. No significant trend was evident at the site in 1993.

5.3 Radioactive Air Particulate Monitoring

5.3.1 Program Overview

Radioactive air particulates are airborne dust particles that carry radioactive contaminants. The primary contributors to long-lived natural background radioactivity on dust particles are decay products of radon. Background concentrations of radioactive air particulates are affected by the amount of contaminants in the soil, moisture, wind, and geological conditions. Many areas on site contain above background concentrations of soil contamination, which could result in increased airborne radioactive particulate concentrations. Increased airborne radioactive particulate emission from the site could result from wind erosion or remedial work activities, such as moving equipment and vehicles in contaminated areas.

The WSSRAP monitors radioactive air particulates using 17 permanent low volume air samplers: seven at the site perimeter, five at the quarry, and at five off-site locations. In addition, three temporary low-volume air monitoring stations were established around the chemical plant perimeter. Depending on the current activities, portable air particulate samplers were deployed at temporary stations. These locations are denoted by an "AP" prefix on Figures 5-1, 5-2, 5-3, and 5-4. In order to monitor alpha particles, low volume air sampler filters were analyzed for long-lived gross alpha activity. These samplers collect airborne



Quarry | Chemical Plant | Raffinate Pits | Off-site

ENVIRONMENTAL TLD 5 YEAR TREND

FIGURE 5-6

REPORT NO.: DOE/OR/21548-436	EXHIBIT NO.: A/PI/011/0394

ORIGINATOR: MAP	DRAWN BY: SRS	DATE: 3/1/94

particulates by drawing ambient air through mixed cellulose ester filters with a 0.80 micron pore size. The filters are then analyzed on a gas flow proportional detector to determine the amount of gross alpha activity in the particulates collected on the filter surface.

A mid-year study indicated decreased monitor pump reliability. It was determined that the 3/4 hp pump motors installed during the 1992 monitor expansion were insufficiently cooled and that proper cooling was not possible with the existing equipment. All 3/4 hp motors were exchanged for 1/4 hp motors during the third quarter. The pump reliability did not effect flow rates and failed pumps were replaced in a timely manner. Fourth quarter results exhibited improved sampling reliability.

5.3.2 Monitoring Results

The annual average long-lived gross alpha concentrations and standard deviations for the 17 permanent and three temporary low volume stations are summarized in Table 5-4. Annual averages were calculated using uncensored weekly air particulate analysis results. Uncensored data refers to all results, including those near or below the minimum detectable amount. The DOE *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (Ref. 32) requires the use of uncensored data to minimize any bias in arithmetic averages and standard deviation calculations.

The typical minimum detectable concentration (MDC) for low volume air particulate sampling at the WSSRAP is 3.3×10^{-16} μCi/ml (0.12 mBq/m^3). This MDC is low enough to allow detection of Th-232, which has the lowest derived concentration guideline (DCG) at the site of 7×10^{-15} μCi/ml (0.26 mBq/m^3) (DOE 5400.5). If an individual inhales airborne contaminants at the DCG for one year, the resulting committed effective dose equivalent is 100 mrem (1 mSv).

5.3.3 Data Analysis

Statistical analysis of the annual results from the low volume airborne particulate samplers indicated that the concentrations of airborne radioactive particulates were greater than background levels at the chemical plant/raffinate pits stations AP-2002, AP-2005, and AP-3004 and at the off-site location AP-4007. The statistical analysis indicated that for all other stations there was no reason to suspect that the results were greater than background.

TABLE 5-4 1993 Radioactive Air Particulate Gross Alpha Results

Monitoring Station Identification Number	Annual Average Long-Lived Gross Alpha Concentration ($\times 10^{-15}$ μCi/ml)[b]	Standard Deviation ($\times$ 1E-15 μCi/ml)	Number of Sample Values Above MDC(c)/Total Number of Samples
AP-2001	1.18	0.62	47/51
AP-2002	1.35	0.63	48/49
AP-3003	1.08	0.44	43/47
AP-3004	1.19	0.50	49/51
AP-2005	1.45	0.70	50/51
AP-4006	1.04	0.47	47/49
AP-4007	1.24	0.49	51/52
AP-4008	1.21	1.00	47/51
AP-1009	1.06	0.64	47/52
AP-1010	0.96	0.41	50/51
AP-4011	1.15	0.46	50/52
AP-4012[a]	1.02	0.50	51/52
AP-2013	1.13	0.50	48/50
AP-3014	1.11	0.42	47/47
AP-1015	1.15	0.61	42/46
AP-1016	1.14	0.49	49/50
AP-1017	1.21	0.72	49/51
AP-2019	1.19	0.45	14/14
AP-2020	0.81	0.52	8/12
AP-2023	0.90	0.50	8/9

(a) Indicates background monitoring station.
(b) The annual average gross alpha concentrations were calculated using uncensored data, which includes analysis results which are less than reported minimum detectable concentrations.
(c) MDC - minimum detectable concentration.
Multiply by 37,000 to convert μCi/ml to Bq/ml

In 1993, several process buildings were dismantled at the chemical plant. This would suggest a potential to release higher concentrations of radioactive airborne particulates than in past years. However, among monitoring stations that failed the statistical analysis, only monitoring station AP-2005 showed 1993 annual average concentrations greater than the comparative 1991 and 1992 annual concentrations.

Background monitoring station AP-4012 had a 1993 annual average of 1.02E-15 μCi/μl (3.77E-11 Bq/ml) and the 1992 annual average was 1.28E-15 μCi/ml (4.74E-11 Bq/ml). This represents a decrease in concentration of approximately 20% for 1993. The decrease is attributed to the change in location of the background station in 1993. In 1993, the background station was moved from the Busch Conservation maintenance building area to the Daniel Boone Elementary School in New Melle. The new setting is in a grassy area with asphalt or concrete in adjacent areas. The old background setting was in the middle of a gravel parking area. Gravel dust has natural radioactivity, and continual sampling of the gravel dust would increase the radioactivity collected on the sampling filter. The lack of fugitive dust created by vehicle traffic on the gravel area is suspected to be the reason for the decrease in the 1993 background concentrations.

It should be noted that the high volume airborne particulate sampler at monitoring station AP-4007 (Busch Conservation Headquarters) collected data in the fourth quarter and did not indicate any increase of radioactive airborne particulate concentrations. The high volume airborne particulate samplers have a flow rate of approximately 950 liters (247 gal) per minute and are more sensitive than the 40 liters (10 gal) per minute low volume samplers. Although the high volume sampler data is used to assess potential doses to critical receptors, the low volume air sampling data will be used to assess any potential impacts to a hypothetical individual at the Busch Conservation Headquarters (AP-4007) as discussed in Section 4.

To assess the effect of fugitive dust on the background low volume monitoring station results, gravel dust samples will be analyzed, dust concentration measurements at the samplers will be collected and compared, and an additional background monitoring station may be established.

5.3.3.1 Chemical Plant/Raffinate Pits. The average concentrations at the chemical plant/raffinate pits perimeter ranged from 8.1E-16 μCi/ml (2.99E-11 Bq/ml) to 1.45E-15 μCi/ml (5.37E-11 Bq/ml). These results are similar to those measured during previous years.

5.3.3.2 Quarry. The average concentrations at the quarry perimeter ranged from 9.6E-16 μCi/ml (3.55E-11 Bq/ml) to 1.21E-15 μCi/ml (4.48E-11 Bq/ml). These results are similar to those measured during previous years.

5.3.3.3 Off-Site. The average concentrations at off-site locations ranged from 1.02E-15 μCi/ml (3.77E-11 Bq/ml) to 1.24E-15 μCi/ml (4.59E-11 Bq/ml). These results are similar to those measured during previous years.

5.4 Unrestricted Area Radioactive Contamination Monitoring

5.4.1 Program Overview

The unrestricted area radioactive contamination monitoring program ensures that areas used by the general public are not contaminated by radioactive materials migrating from the site as a result of remedial activities. Monitoring consists of in situ measurements (fixed contamination) and swipe sample (removable contamination) collection.

The unrestricted area radioactive contamination monitoring program includes radiological surveys in both the controlled and uncontrolled areas at the site. Site roadways and the quarry bulk waste haul road are monitored to ensure that removable contamination is kept free from these accessible areas. The Katy Trail is surveyed since it is used by the public.

Ten roadway areas outside the site controlled areas and 10 locations on the Katy Trail (between the Femme Osage Slough and the quarry) are routinely surveyed. Starting in the fourth quarter 1993, periodic contamination surveys were conducted on the quarry bulk waste haul road. Thirty locations were surveyed on the haul road. Variations in monitoring locations are made to check for any contamination over the entire investigated portion of the haul road and Katy Trail. To date, these surveys confirm radioactive contamination has not been carried into unrestricted areas.

In situ measurements are taken with a beta-gamma detector. One minute measurements are collected to provide the total (removable plus fixed) radioactivity within the tested area. Swipes are then wiped over an approximate 100 cm^2 (15.5 in^2) area with a dry cloth or paper swipe. The swipe is analyzed using an alpha scintillation detector. The count rates are corrected to account for detector efficiency. The swipe measurement provides removable radioactivity in dpm/100cm^2.

5.4.2 Monitoring Results

The site roadway surveys indicated an annual removable average alpha radioactivity level for all monitoring locations of 0.35 dpm/100 cm^2. The highest level was 3.84 dpm/100 cm^2. The average minimum detectable activity (MDA) for alpha radioactivity was 4.5 dpm/100 cm^2. The roadway surveys indicated an annual average fixed beta-gamma radioactivity levels for all monitoring locations of 550 dpm/100 cm^2; the highest level was 1,870 dpm/100 cm^2. The average MDA for beta-gamma radioactivity was 549 dpm/100 cm^2.

The Katy Trail survey indicated an annual average alpha radioactivity level for all monitoring locations of 0.90 dpm/100 cm^2; the highest level was 5.2 dpm/ 100cm^2. The average MDA for alpha radioactivity measurements is 4.3 dpm/100 cm^2. The survey indicated an annual average beta-gamma radioactivity level for all monitoring locations of 420 dpm/100 cm^2; the highest level was 1,140 dpm/100 cm^2.

The fourth quarter haul road surveys indicated a range of removable alpha radioactivity of -0.68 dpm/100cm^2 to 9.8 dpm/100cm^2, with an average of 0.01 dpm/100cm^2. The range of beta-gamma radioactivity was 0.0 dpm/100cm^2 to 1061 dpm/100cm^2, with an average of 252 dpm/100cm^2. The MDA for removable alpha radioactivity and beta-gamma radioactivity was 3.8 dpm/100cm^2 and 619 dpm/100cm^2, respectively. Most measurements were below the MDA. The annual averages are based upon actual not survey results whether negative, positive, or zero.

5.4.3 Data Analysis

The site monitoring results show fixed contamination present in a few locations, but at levels well below the DOE uranium surface contamination guidelines for unrestricted use (5,000 dpm/cm^2 or 5,000 dpm/15.5 in^2). The contamination was probably caused by airborne uranium deposits that occurred during Weldon Spring Uranium Feed Material Plant operations. No increase in removable contamination levels has been measured since the monitoring program was initiated.

The Katy Trail and quarry haul road monitoring results indicate background radiation levels. These data indicate that no contamination from the quarry is migrating to the quarry haul road or the Katy Trail, and thus, there is no identifiable probability of radiological contamination to users of the trail or haul road.

5.5 Airborne Asbestos Monitoring

During 1993, environmental monitoring for asbestos was conducted full time at Francis Howell High School (AP-4006) and at the site perimeter. In mid-January, full time monitors were placed around the site perimeter (AP-2002, AP-3003, AP-2013, and AP-2019) to monitor asbestos abatement operations. In August, full time asbestos monitors were also placed at the quarry perimeter (AP-1009, AP-1010, and AP-1015). See Figures 5-1 and 5-2 for monitoring locations. Filters were collected weekly and shipped off site for analysis.

Two methods are utilized to analyze asbestos samples. Phase contrast microscopy (PCM) indicates fibers that have the same size and shape as asbestos; however, this method does not distinguish between asbestos and nonasbestos fibers. Transmission electron microscopy (TEM) measures the actual asbestos fiber concentrations.

TEM was used for primary asbestos analysis until December 1993, when all asbestos samples were analyzed using the PCM method.

The results of the environmental samples collected at the Francis Howell High School and the site and quarry perimeter are provided in Table 5-5. A total of 281 samples were collected with only 11 samples indicating results above the detection limits. The range of samples above the detection limits is 0.0006 fibers per milliliter of air (f/ml) to 0.0022 f/ml.

The environmental air samples collected from the site and quarry perimeters and Francis Howell High School are all below fiber concentrations as defined by the EPAs acceptable clearance levels for schools. These results indicate that asbestos fibers were effectively contained during abatement operations.

TABLE 5-5 Summary of Asbestos Air Monitoring Results

Location	Number of Samples/Samples Above Detection Limit	Range[a]	Average[a]
AP-2002	48/1	0.0006	0.0006
AP-2013	48/3	0.0006-0.0022	0.0012
AP-2019	48/3	.0006-0.0013	0.0010
AP-3003	47/1	0.0013	0.0013
AP-4006	44/3	0.0006[b]	0.0006
AP-1009	13/0	N/A	N/A
AP-1010	15/0	N/A	N/A
AP-1015	18/0	N/A	N/A

(a) Includes only samples above detection limits.
(b) All samples had the same results.
N/A No range or average calculated. All samples were below the detection limit.

5.6 Highlights

- Statistical analysis indicated that five radon monitors located at the quarry and five locations at the site were statistically greater than background. The highest measured concentration was 40% of the derived concentration guideline (DCG) for Rn-222.

- TLD results from the chemical plant, quarry, and off-site locations ranged from 48 mrem to 73 mrem. Monitoring result statistical analysis indicates (at the 95% confidence level) there is no reason to suspect these values are greater than background.

- Asbestos analysis showed fiber concentrations below the EPA acceptable clearance levels for schools.

- Statistical analysis indicated that three gross alpha airborne particulate monitors at the chemical plant/raffinate pits perimeters and one off-site monitor location have annual average concentrations statistically greater than background levels. The highest measured annual average concentration was 21% of the DCG for Th-232, which is the lowest DCG at the site, and 0.07% of the DCG for U-238, which is the primary contaminant at the site.

6 SURFACE WATER PROTECTION

6.1 Program Overview

The environmental monitoring and protection program for surface waters at the Weldon Spring Site Remedial Action Project (WSSRAP) includes monitoring discharge points under the National Pollutant Discharge Elimination System (NPDES) program and monitoring streams, ponds, and lakes under the surface water monitoring program.

The effluent or NPDES monitoring program at the Weldon Spring site establishes sampling requirements for discharge points (outfalls) at both the chemical plant and the quarry. The goals of this program are to maintain compliance with NPDES permit requirements and to characterize water released from the site to protect the health of downstream water users and the environment.

To protect public water sources, the surface water monitoring program monitors existing or potential surface water contamination. Additional goals include demonstrating compliance with all applicable regulations and Department of Energy Orders, providing sufficient data to determine long term build up, and the detection and quantification of unplanned releases.

6.2 Applicable Standards

The WSSRAP is subject to, and complies with, Executive Order 12088, which requires all Federal facilities to comply with applicable pollution control standards. Effluent discharges from the site for 1993 were authorized by six NPDES permits issued by the Missouri Department of Natural Resources (MDNR). The MDNR requires specific parameters to be sampled under each permit. Each parameter is assigned effluent limits or a "monitoring only" status, which means the concentrations are reported but not limited by the permit. Sampling frequencies and reporting requirements for two permits are summarized in Tables 6-1 and 6-2, respectively. Permits MO-G680002, MO-G680004, and MO-G80005 are for hydrostatic test water for the treatment plants and associated pipelines. These permits require sampling once per batch and there are permit limits for flow (gallons), oil and grease (15 mg/l), and total suspended solids (50 mg/l). In addition, the sixth permit, the site water treatment plant effluent pipeline land disturbance permit (MO-R101389) has one monitoring requirement for settleable solids to be measured once per quarter.

TABLE 6-1 Weldon Spring Chemical Plant Storm and Sanitary Water (NPDES Permit MO-0107701) Monitoring Requirements

Parameter	Location		
	NP-0002, NP-0003, NP-0005	NP-0001, NP-0004	NP-0006
Sampling Frequency	once/month	once/quarter	once/quarter
Flow	GPD (monitor only)	GPD (monitor only)	GPD (monitor only)[b]
Settleable Solids	1.0 ml/l/hr[a]	1.0 ml/l/hr[a]	---
TSS	mg/l (monitor only)[c]	mg/l (monitor only)[c]	15 / 20 mg/l[d]
Nitrate as N	mg/l (monitor only)	mg/l (monitor only)	---
Lithium	mg/l (monitor only)	mg/l (monitor only)	---
Uranium, total	mg/l (monitor only)	mg/l (monitor only)	—
Gross α	pCi/l (monitor only)	pCi/l (monitor only)	—
pH	6 - 9 standard units[a]	6 - 9 standard units[a]	6 - 9 standard units
Fecal coliform	---	—	400/1000 colonies/ 100 ml[e]
BOD	---	—	10/15 mg/l[d]

NOTE: Refer to Figure 6-1 for NPDES monitoring locations.

(a) Limits apply after date of *Record of Decision* (September 17, 1993) (Ref. 10); "monitor only" requirements apply until that date.
(b) Frequency is once/month for NP-0006 flow monitoring.
(c) Limit is 50 mg/l if erosion control is not designed for 1 in 10 year, 24 hour storm.
(d) Monthly average / weekly average.
(e) Monthly average / daily maximum.

TABLE 6-2 Treated Effluent Parameter Limits and Monitoring Requirements for Quarry Water Treatment Plant (NPDES Permit MO-0108987) and Site Water Treatment Plant (NPDES Permit MO-0107701)
(Frequency = once/batch unless otherwise noted)

Parameter	Location NP-0007 NP-1001	Location SW-1011 SW-1012 SW-1016 SW-1015	Parameter	Location NP-0007 NP-1001	Location SW-1011 SW-1012 SW-1016 SW-1015
Gross α	pCi/l[a]	pCi/l[a]	Pb, total	0.10 mg/l	NR
Gross ß	pCi/l[a]	pCi/l[a]	Mn, total	0.10 mg/l	NR
Uranium, total	pCi/l[a][h]	pCi/l[a]	Hg, total	0.004 mg/l	NR
Ra-226	pCi/l[a]	pCi/l[a]	Se, total	0.02 mg/l	NR
Ra-228	pCi/l[a]	pCi/l[a]	Ag, total	0.10 mg/l	NR
Th-230	pCi/l[a]	pCi/l[a]	Zn, total	5.00 mg/l	NR
Th-232	pCi/l[a]	pCi/l[a]	Cyanide, total	0.0075 mg/l	NR
Flow	GDP[a]	NR	Asbestos	fibers/l[a]	NR
BOD	mg/l[a]	NR	2,4-DNT	0.22 µg/l	NR
COD	90/60 mg/l [b]	NR	Fluoride, total	4.0 mg/l	NR
TSS	50/30 mg/l[b]	NR	Nitrate as N	20 mg/l[c]	NR
pH	6-9 standard units	NR	Sulfate as SO_4	500 mg/l	NR
As, total	0.10 mg/l	NR	Chloride	mg/l[a]	NR
Ba, total	1.6 mg/l	NR	Priority Pollutants	mg/l[a][g]	NR
Cd, total	0.02 mg/l	NR	Whole Effluent Toxicity	10% Mortality[f]	NR
Cr, total	0.1 mg/l	NR	Po-210[d]	pCi/l[a][e]	NR
Cu, total	1.00 mg/l	NR	Ac-227[d]	pCi/l[a][e]	NR
Fe, total	0.60 mg/l	NR	Radon[d]	pCi/l[a][e]	NR

NOTE: Refer to Figure 6-2 for NPDES monitoring locations

(a) Monitoring only.
(b) Daily maximum/monthly average.
(c) Limit applies only to chemical plant, monitoring only at quarry.
(d) NP-1001 only.
(e) Semi-annual monitoring.
(f) Quarterly monitoring
(g) Annual monitoring.
(h) Water treatment plant designed for an average concentration of 30 pCi/l and never to exceed concentrations of 100 pCi/l.
NR Not Required

Discharge monitoring reports are not required for this permit, although MDNR notification is required if settleable solids exceed the reporting level of 2.5 ml/l/hr. Table 3-4 also lists the NPDES permits.

Effluent discharges are also regulated by Department of Energy (DOE) Order 5400.5, which calls for a best available technology evaluation if the annual average uranium concentration at the outfall exceeds the derived concentration guideline for natural uranium (600 pCi/l).

The main criteria used to develop the surface water monitoring program were the Missouri Water Quality Standards established under the Missouri Clean Water Commission Regulation (10 CSR 20-7.031) and the proposed U.S. Environmental Protection Agency drinking water standards for radionuclides. A list of applicable water standards for contaminants routinely monitored in the surface water program can be found in Section 7 (Table 7-1).

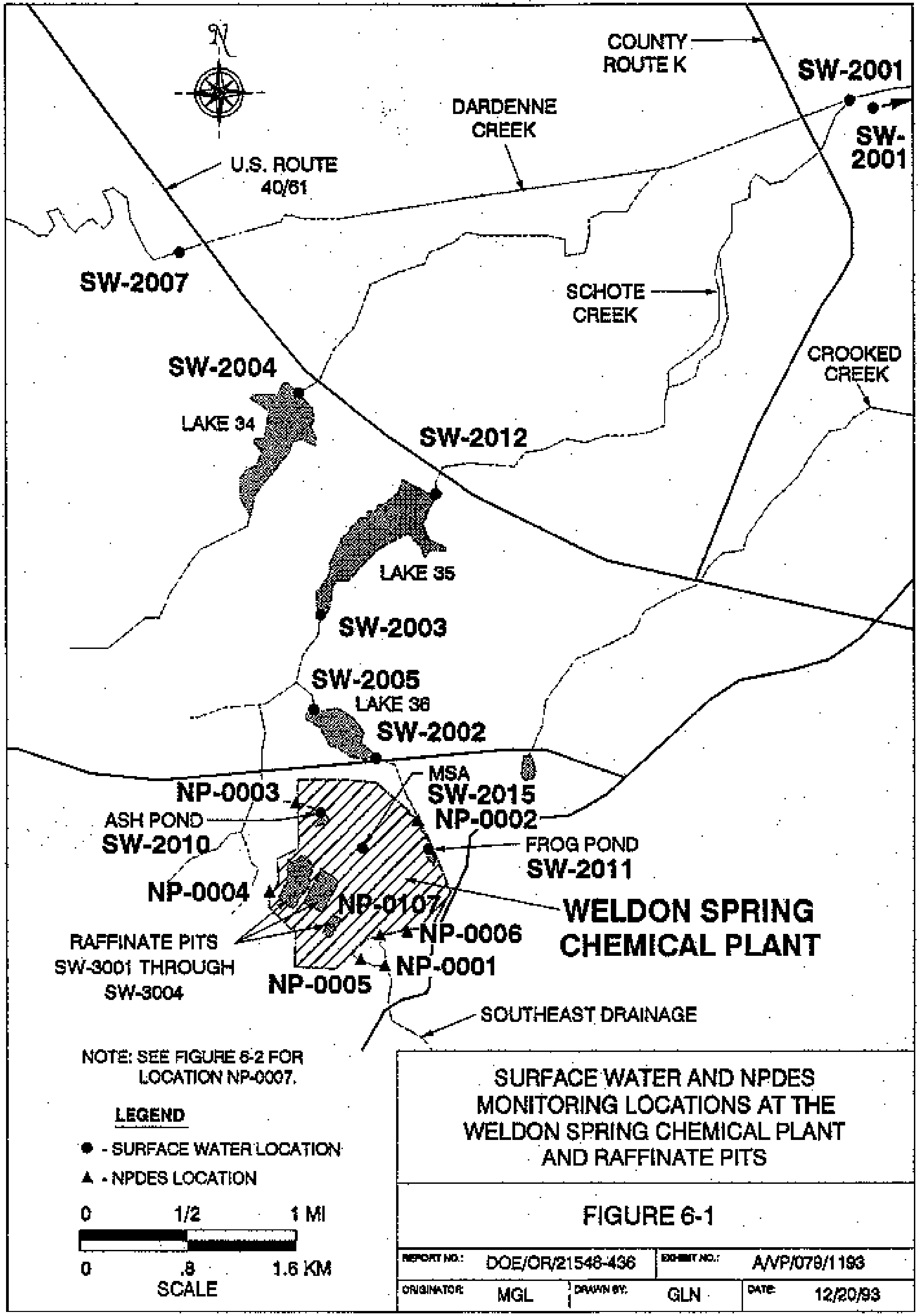
Surface water is also monitored under the requirements of DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, which designates derived concentration guidelines (DCGs) for ingestion of water (see Table 7-2).

6.3 Hydrology

Separate surface water monitoring programs have been developed at the chemical plant and quarry due to differences in the topography and hydrologic conditions. Both programs take into account the mechanisms controlling surface water and ultimately groundwater movement.

6.3.1 Weldon Spring Chemical Plant and Weldon Spring Raffinate Pits

The chemical plant area is located on the Missouri-Mississippi rivers surface drainage divide. The topography is gently undulating and generally slopes northward to the Mississippi River. Streams do not cross the property, but incipient drainageways convey surface water runoff to off-site streams. Surface drainage from the northern and western portions of the site drain to tributaries for Busch Lake 35 and then to Schote Creek, which in turn enters Dardenne Creek, ultimately draining to the Mississippi River (Figure 6-1). Surface drainage from the chemical plant's abandoned storm water sewer and Frog Pond also discharges to Dardenne Creek after flowing through Busch Lakes 35 and 36 into Schote Creek. Runoff from the



SURFACE WATER AND NPDES MONITORING LOCATIONS AT THE WELDON SPRING CHEMICAL PLANT AND RAFFINATE PITS

FIGURE 6-1

REPORT NO.:	DOE/OR/21548-436	EXHIBIT NO.:	A/VP/079/1193
ORIGINATOR: MGL	DRAWN BY: GLN	DATE:	12/20/93

southern portion of the chemical plant site flows southeast to the Missouri River via the Southeast Drainage (Valley 5300).

The four raffinate pits, located in the southwestern portion of the chemical plant area, have no discharge structures and collect only direct precipitation. The material staging area basin (SW-2015) is a temporary holding pond that collects storm water runoff from the staging area. After monitoring, this impoundment is periodically pumped into the Ash Pond diversion channel, which ultimately flows to NPDES outfall NP-0003 and then to Busch Lake 35.

6.3.2 Weldon Spring Quarry

Surface water within the quarry consists of the quarry pond, which acts as a storm water sump and also intercepts and collects groundwater (Figure 6-2). There is no direct surface water runoff from the quarry; however, contaminated groundwater from the quarry moves through the bedrock and fine-grained alluvium into the Femme Osage Slough. Flow from the slough into the Missouri River is controlled by the river and slough stages, and a valve and discharge pipe.

The Little Femme Osage Creek is located adjacent to the western side of the quarry site. This creek discharges into the Femme Osage Creek about 1.6 km (1 mi) upstream of its confluence with the Missouri River. No direct runoff from the quarry area discharges into either creek.

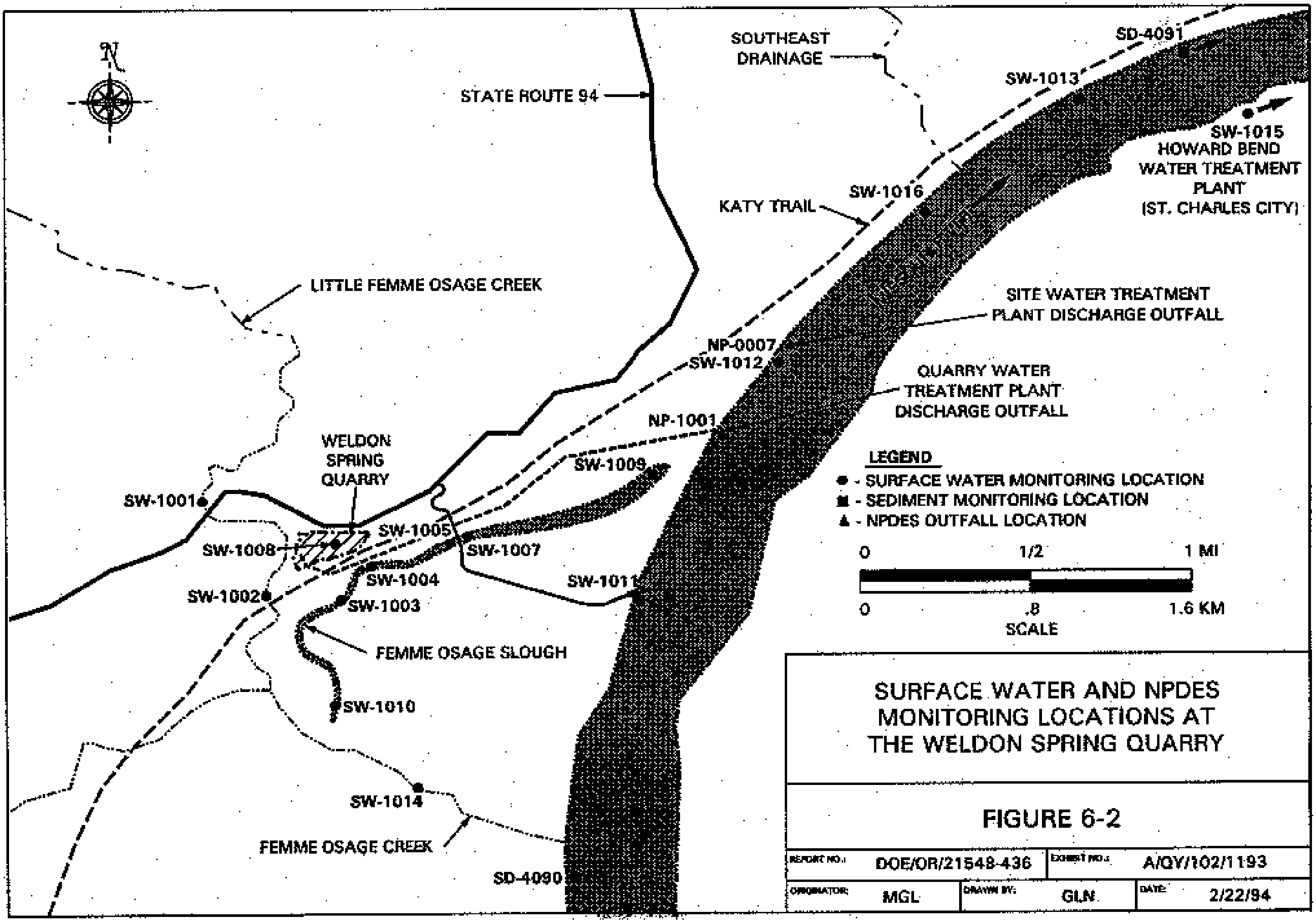
6.4 Monitoring Programs

6.4.1 National Pollutant Discharge Elimination System Program

Physical and chemical parameters were monitored for at all storm water and hydrostatic test water samples. Additional parameters were monitored in the quarry water treatment plant and site water treatment plant effluents and in storm water samples collected for required permit application analyses.

6.4.2 Surface Water Program

6.4.2.1 Weldon Spring Chemical Plant and Weldon Spring Raffinate Pits. Dardenne Creek, Busch Lakes 34, 35, and 36, Frog Pond, and Ash Pond were sampled



SURFACE WATER AND NPDES MONITORING LOCATIONS AT THE WELDON SPRING QUARRY

FIGURE 6-2

REPORT NO.: DOE/OR/21548-436		EXHIBIT NO.: A/QY/102/1193
ORIGINATOR: MGL	DRAWN BY: GLN	DATE: 2/22/94

quarterly for total uranium, semi-annually for nitrate and sulfate, and annually for Ra-226, Ra-228, Th-228, Th-230, Th-232, gross alpha, and gross beta. The raffinate pits were sampled annually for total uranium; semiannually for nitrate and sulfate, and quarterly for radon, Ra-226, Ra-228, isotopic thorium, gross alpha, and gross beta.

The material staging area basin was sampled quarterly (beginning with the third quarter) for arsenic, barium, cadmium, lead, chromium, mercury, selenium, silver, magnesium, polychlorinated biphenyls, total petroleum hydrocarbons, and total organic carbon. Total uranium was determined for each batch of water prior to discharge.

6.4.2.2 Weldon Spring Quarry. The quarry pond and seven locations within the Femme Osage Slough were monitored to determine the impact of groundwater infiltration from the quarry. Two locations on the Little Femme Osage Creek and one location at the Femme Osage Creek were monitored to provide data on areas of potential impact from the quarry. Three locations on the Missouri River were also monitored.

All locations were sampled bimonthly for total uranium due to the fluxations in the concentrations possibly resulting from changing water levels in the slough and the possible impacts of contaminants in the slough on downgradient groundwater. All locations were also monitored at least annually for arsenic, barium, nitrate, sulfate, nitroaromatic compounds, and other radiochemical parameters, including Ra-226, Ra-228, Th-228, Th-230, Th-232, gross alpha, and gross beta to provide baseline data and early detection for these parameters within surface water bodies near the quarry due to the potential impact to groundwater. The quarry pond is monitored bimonthly for the previously mentioned parameters, with the exception of arsenic and barium, to maintain surveillance of the contaminants in the quarry bulk wastes.

6.5 Monitoring Results

6.5.1 National Pollutant Discharge Elimination System Program

6.5.1.1 Radiochemical Analysis. The 1993 average uranium concentrations at the storm water discharge points ranged from 9 pCi/l (0.33 Bq/l), which is 1.3% of the DCG, at NP-0004 to 1003 pCi/l (37.11 Bq/l), which is 148% of the DCG at NP-0001. Annual average gross alpha concentrations ranged from 13.4 pCi/l (0.50 Bq/l) at NP-0004 to 1080 pCi/l (40 Bq/l) at NP-0001. The annual average radionuclide concentrations for all the storm water outfalls are shown in Table 6-3. Uranium concentration averages were calculated on a flow proportional basis in Table 6-3. Appendix A averages were not calculated on a flow proportional basis.

TABLE 6-3 1993 Annual Average NPDES Results for the Weldon Spring Chemical Plant Storm Water Outfalls

Location	Number of Samples	pH Range	Total Uranium (pCi/l)**	Gross Alpha (pCi/l)	Nitrate as N (mg/l)	Lithium (mg/l)	Suspended Solids (mg/l)	Settleable Solids (ml/l)	Oil and Grease (mg/l)
NP-0001	5	(a)	1003	1080	0.261	0.011	12.5	<0.1	NS
NP-0002	12	(a)	230	264.6	0.642	0.011	14.4	<0.1	NS
NP-0003	12	(a)	607	644.5	2.234	0.011	9.7	<0.1	NS
NP-0004	4	(a)	9	13.4	0.320	0.009	5.8	<0.1	NS
NP-0005	12	(a)	133	343.9	0.210	0.013	23.3	<0.1	NS
NP-TSAB	9	(a)	1.7	1.8	1.865	0.012	21.1	<0.1	2.5

(a) All pH readings were in permitted range of 6.0 to 9.0.
** Flow proportional averages except for NP-TSAB

The site water treatment plant (SWTP) and quarry water treatment plant (QWTP) were both in operation during 1993. Fifteen batches were discharged from the QWTP and 15 batches were discharged from the SWTP. No daily maximum or monthly average limit was proposed for uranium; the design of the treatment plant is based on achieving an average discharge of 30 pCi/l uranium with a maximum never to exceed 100 pCi/l (3.7 Bq/m^3). The average uranium concentrations for both treatment plants were below 1.9 pCi/l (0.07 Bq/l). The averages for all radiological parameters are given in Appendix A.

Hydrostatic test water was discharged from the quarry water treatment plant and basins, the site water treatment plant basins, and the temporary storage area basin. Storm water was also discharged from the temporary storage area basin. Hydrostatic test water was discharged from uncontaminated areas; therefore, radiological monitoring was not a requirement of these NPDES permits, and the water was discharged and monitored as storm water and hydrostatic test water. The annual average uranium and gross alpha concentrations of temporary staging area effluent were 0.95 pCi/l (0.04 Bq/l) and 1.72 pCi/l (0.06 Bq/l), respectively.

Estimated quantities of total uranium released off site through surface water runoff and treatment plant discharges are presented in Table 6-4. The total volume of storm water was determined from totalizing flow meters. Where flow meters were not available or were not in operation, the flow was determined by total precipitation and runoff curve numbers cited in the *WSSRAP Chemical Plant Surface Water and Erosion Control Report* (Ref. 33) or by calculating a ratio of monthly precipitation to monthly total runoff from months when the flow meters were operating. Total uranium released from the treatment plants was calculated using flow meter and effluent data.

Annual average uranium concentrations for NPDES outfalls from 1989 to 1993 are shown in Table 6-5. Concentrations in 1993 increased at outfalls NP-0001 and NP-0003, decreased at outfall NP-0005, and did not change appreciably at outfalls NP-0002 and NP-0004 compared to 1992 concentrations. Each outfall is discussed below.

Outfall NP-0001 is the abandoned process sewer. This sewer has been blocked at a manhole upstream of the outfall and the contents of the process sewer upstream of the manhole are pumped to the site water treatment plant. The only water in the process sewer downstream of the manhole is storm water infiltration or inflow. The increase in the average uranium concentration (1,003 pCi/l) for 1993 to above the DCG of 600 pCi/l has been attributed to inflow from a storm water source upstream of outfall NP-0005. This source flows in a ditch that crosses over the process sewer. It was discovered that the flow in the ditch was going underground and entering the process sewer. This source is a minor contributor to outfall NP-0005, but when it was entering the process sewer it comprised the major portion of NP-0001 flow. The source of the high uranium levels is being investigated and corrective action will be taken when the cause is found.

Average uranium concentration for Outfall NP-0002 in 1993 remained essentially the same as 1992. There was an elevated level detected in December, but the source was located and that water was diverted to the site water treatment plant.

The average uranium concentration for outfall NP-0003 at 607 pCi/l (22.5 Bq/l) was slightly above the derived concentration guide of an annual average of 600 pCi/l (22.2 Bq/l). The increase was a result of higher annual precipitation than normal, which caused the contribution from Ash Pond to be higher than usual. In the past, Ash Pond water has typically

TABLE 6-4 1993 Estimated Annual Release of Natural Uranium from NPDES Outfalls

Outfall	Drainage Area Hectares (Acres)	% of Precipitation as Runoff[b]	Average Concentration (pCi/l)	Total Rainfall Volume (Mgal/yr)	Total Runoff (Mgal/yr)	Total U Release (Ci/yr)	Total U Release (Kg/yr)
NP-0001 NP-0005	(8.2) 20.2	N/A	351[a]	30.04	15.87[a]	2.106×10^{-2}	30.97
NP-0002	(30.4) 75.1	N/A	230	111.67	51.85	4.508×10^{-2}	66.29
NP-0003	(30.2) 74.6	N/A	607	110.92	48.15	11.060×10^{-2}	162.65
NP-0004	(2.3) 5.6	81	9	8.33	6.74	22.929×10^{-5}	0.34
NP-0007	N/A	N/A	0.363	-	11.72[c]	1.610×10^{-5}	0.02
NP-1001	N/A	N/A	1.881	-	10.15[c]	7.226×10^{-5}	0.11
TOTAL	(71.1) 175.5	N/A	N/A	260.96	122.61	0.177	260.38

(a) Assuming flow at NP-0005 is three times the flow at NP-0001 (conservative)
(b) Runoff Curve Number
(c) Not included in total runoff
N/A Not Applicable

TABLE 6-5 Annual Average Uranium Concentrations at NPDES Outfalls 1989 - 1993

Outfall	Annual Average Total Uranium (pCi/l)				
	1989	1990	1991	1992	1993
NP-0001	368	413	475	516	1003*
NP-0002	145	139	158	229	230*
NP-0003	280	89	456	478	607*
NP-0004	7	8	6	6	9*
NP-0005	347	364	581	296	133*
NP-0007	--	--	--	--	0.363
NP-1001	--	--	--	< 0.0003	1.881

* Flow proportional average.

been in the 1000 pCi/l (37 Bq/l) range, but usually only discharged from December through March. A return to normal precipitation should result in a drop in uranium at NP-0003. Storm water from upstream activities will be closely monitored to exclude those activities as contributors to the increase.

Uranium levels at outfall NP-0004 remain essentially the same as previous years, while uranium levels at outfall NP-0005 have decreased by more than 50%. This decrease may be attributable to the cleanup of the site water treatment plant construction area and also the diversion of an upstream source as explained above in the NP-0001 discussion.

6.5.1.2 Physical and Chemical Results.

6.5.1.2.1 Chemical Plant Storm Water. The annual averages for the physical and chemical parameters for storm water outfalls NP-0001 through NP-0005 and the temporary storage area basin water are shown in Table 6-3. Parameters that are not listed in Table 6-3 are reported in Appendix A.

6.5.1.2.2 Site and Quarry Water Treatment Plant Physical and Chemical Parameters. Physical and chemical parameters were all within permitted limits (where limits were assigned) for the site and quarry water treatment plants. Averages for these parameters are given in Appendix A.

6.5.1.2.3 Administration Building Sewage Treatment Plant. The parameters required by the NPDES permit for the sewage treatment plant are all physical and chemical. The treatment plant was shutdown for modifications until July 5, 1993. Before that date the sewage was hauled away by a contract hauler. Monitoring results for sewage treatment plant outfall NP-0006 are given in Table 6-6. Noncompliances with permit limits occurred during October and December for TSS and BOD. The subcontractor has implemented accelerated operational monitoring to allow more information for operational changes to maintain compliance.

TABLE 6-6 NP-0006, Sewage Treatment Plant Outfall, Monthly Averages of Permitted Parameters

	Parameter[a]			
Month	TSS (15/20 mg/l)*	BOD (10/15 mg/l)*	FC[b] (400/ 1000 col/100 ml)**	pH (6.0-9.0 SU)
Jan - June	No Discharge			
July	3	1	0	6.8
August	2	6	80	6.0
September	12	6	0	6.5
October	25.5(2)	24(2)	0	6.8
November	NS	NS	NS	NS
December	18(2)	12(2)	0(1)	7.0(2)

(a) Number of samples given in parentheses after average.
(b) F.C - fecal coliform.
NS Not Sampled
* Monthly average/weekly average
** Monthly average/daily maximum

6.5.2 Surface Water Program

6.5.2.1 Weldon Spring Chemical Plant and Weldon Spring Raffinate Pits.

Offsite Locations:

Radiochemical Parameters - With the exception of location SW-2001, surface water at off-site monitoring locations remained within historic ranges for uranium. A new high of 10.0 pCi/l was measured in April at SW-2001. Subsequent measurements at this location showed that uranium concentrations were at background levels. The cause of the elevated uranium measurement in April is not known. All remaining radiological parameters were within historic ranges at all locations sampled.

Inorganic Anions - Sulfate and nitrate remained within historic values during the 1993 monitoring period. These parameters will be removed from the monitoring program in 1994 because they have remained within background ranges at these off-site locations.

On-Site Locations:

Radiochemical Parameters Uranium and other radiological parameters remained within historic ranges at all on-site locations. Radon, which has not been routinely measured, was measured three times in each of the raffinate pits (SW-3001 - SW-3004). The results, which were somewhat erratic, were not proportional to uranium or Ra-226 concentrations in the raffinate pits.

Anions, Metals, and other Parameters: Sulfate, nitrate, and nitroaromatics were within historic ranges in each of the raffinate pits (SW-3001 - SW-3004). Pesticides, PCBs and total petroleum hydrocarbons were measured in Raffinate Pit 4 (SW-3004) and were below the limit of detection. Arsenic, cadmium, chromium, and manganese were also measured in Raffinate Pit 4 and were near or below the limit of detection.

At Frog Pond (SW-2011) and Ash Pond (SW-2010), nitrate and sulfate were within historic ranges. Lithium was not detected or was present at low levels. Arsenic and mercury were not detected during the single sampling for these parameters. Asbestos was measured for the first time at these locations and was near or below the detection limit.

6.5.2.2 Weldon Spring Quarry.

Radiochemical Parameters. The average total uranium values continue to indicate the highest levels for surface water are found in the quarry pond (SW-1008), which is within the quarry area, and the portion of the Femme Osage Slough (SW-1003 through SW-1005 and SW-1010) down gradient of the quarry. The annual averages for the surface water locations are summarized in Appendix A. The uranium levels in the quarry pond ranged from 360 pCi/l to 9000 pCi/l with an annual average of 3857 pCi/l, which is higher than the historical average of 1686 pCi/l. This increase is attributed to bulk waste removal activities in the quarry. The total uranium levels in the Little Femme Osage Creek and the Femme Osage Creek remained at or below the background level of 1.70 pCi/l. The uranium levels in the Missouri River also remained within the background level of 4.08 pCi/l.

The DCG for total uranium in drinking water systems is 24 pCi/l, which is 4% of the DCG for total uranium in discharge waters (600 pCi/l). This criterion was used for the Missouri River because the river is a source of drinking water. This value was not exceeded in any of the Missouri River samples. The proposed U.S. Environmental Protection Agency Drinking Water Standard of 20 μg/l (13.6 pCi/l) for total uranium was not exceeded at any of the Missouri River monitoring locations.

The first bimonthly surface water sample collected from location SW-1004 in the Femme Osage Slough indicated a uranium concentration of 4,012 pCi/l. This value was noticeably higher than the historic high of 557 pCi/l. The sample was reanalyzed and the elevated level was confirmed. The analysis of the resampling event in March 1993 indicated a concentration of 100 pCi/l. An investigation of the difference between the sampling conditions for the two separate events was initiated, and it was concluded that it was an effect of the flooded condition in the well field and is further discussed in detail in Section 10.

The quarry surface water locations were sampled annually for gross alpha and gross beta, except for the quarry pond, which was sampled bimonthly. The gross alpha and gross beta results for these locations were within historic ranges for the Little Femme Osage Creek, the Femme Osage Creek, and the Missouri River. Elevated gross alpha levels were indicated in the western portion of the Femme Osage Slough (SW-1003 through SW-1005, and SW-1010) but were within historic ranges. The gross alpha levels in the quarry pond ranged from 240 pCi/l to 6900 pCi/l with an annual average of 3132 pCi/l and gross beta levels ranged from 93 pCi/l to 2860 pCi/l with an annual average of 1151 pCi/l. These increases are also attributed to the bulk waste removal activities in the quarry. The annual averages for these monitoring locations are summarized in Appendix A.

The Missouri Drinking Water Standard of 15 pCi/l for gross alpha was exceeded at one Missouri River monitoring location (SW-1012) and 50 pCi/l for gross beta was not exceeded in the Missouri River. The annual average gross alpha at SW-1012 was within background ranges established at SW-1011. Background for the Missouri River is 11.6 pCi gross alpha and 16.2 pCi gross beta.

Isotopic radium (Ra-226 and Ra-228) and thorium (Th-228, Th-230, and Th-232) were analyzed annually during 1993 at surface water locations around the quarry and bimonthly in the quarry pond. The levels of these isotopes were at or below background ranges in the Little Femme Osage Creek, the Femme Osage Creek, and the Missouri River. The levels of these isotopes were within historic ranges in the Femme Osage Slough and the quarry pond. The annual averages for the monitoring locations are summarized in Appendix A.

The DCGs for Ra-226, Ra-228, Th-230, and Th-232 in drinking water, as established by Department of Energy Order 5400.5, are 4% of the respective DCG for each isotope in the discharge water. This criterion was used for the Missouri River because the river is a source of drinking water. These values were not exceeded at any of the Missouri River monitoring locations.

Nitroaromatic Compounds

Nitroaromatic compounds were analyzed at all quarry surface water locations. Three locations, the Little Femme Osage Creek (SW-1001 and SW-1002) and the quarry pond (SW-1008), indicated detectable concentrations of nitroaromatic compounds. The annual averages for all the surface water monitoring locations are summarized in Appendix A. The concentration of 2,4,6-trinitrotoluene (TNT) in the quarry pond was elevated but was within historic ranges. The remaining nitroaromatic compounds detected in the quarry pond were within historic ranges. The concentrations detected in the Little Femme Osage Creek may be linked to the former Weldon Spring Ordnance Works. The Little Femme Osage Creek is located in a drainage (Valley 5600) which is a main southerly drainage for the ordnance works area. Previous sampling of the Little Femme Osage Creek and several springs located upstream which discharge into this valley have yielded detectable concentrations of nitroaromatic compounds. The Federal ambient water quality standard of 0.11 μg/l for 2,4-dinitrotoluene (DNT) was exceeded only in the quarry pond.

Inorganic Anions

All surface water monitoring locations at the quarry were sampled once in 1993 for nitrate (as N) and sulfate. The analyses indicated nitrate concentrations were within background ranges in the quarry pond, the Little Femme Osage Creek, the Femme Osage Creek, and the Missouri River. Nitrate concentrations were elevated but within background ranges in the Femme Osage Slough. The annual averages for nitrate at the quarry surface water monitoring locations are summarized in Appendix A. The maximum contaminant level (MCL) standard for nitrate (10 mg/l) was not exceeded at any of the quarry surface water monitoring locations.

Sulfate levels in all surface waters monitored in and around the quarry were within background ranges The annual averages for sulfate in surface waters are summarized in

Appendix A. The MCL standard for sulfate (250 mg/l) was not exceeded at any of the quarry surface water monitoring locations.

Metals

The quarry surface water monitoring locations were sampled once in 1993 for arsenic and barium. The arsenic levels were within background ranges for all surface water monitoring locations in and around the quarry. The annual averages for arsenic are summarized in Appendix A. The MCL for arsenic (50 μg/l) was not exceeded at any of the monitoring locations.

Barium levels were within background ranges for all surface water monitoring locations in and around the quarry. Barium levels in the western portions of the Femme Osage Slough were elevated by within historic levels. Annual averages are shown in Appendix A. The MCL for barium (1000 μg/l) was not exceeded at any of the monitoring locations.

6.6 Highlights

- The first bimonthly surface water sampled collected from the portion of the slough downgradient from the quarry (SW-1004) indicated a historically high total uranium concentration of 4,012 pCi/l. An investigation, including resampling of the locations, concluded that the elevated level was the effect of flooding of the slough, which caused the intermingling of highly contaminated groundwater with the surface water of the slough. Subsequent sampling of the slough has indicated that the total uranium levels have returned to typical ranges.

- Surface water locations along the Missouri River, Femme Osage Slough, Femme Osage Creek, and Little Femme Osage Creek were unable to be sampled during the third quarter due to flooding of the Missouri River.

- Analysis of the quarry sump (SW-1008) indicated elevated levels of gross alpha, gross beta, total uranium, and nitroaromatic compounds. These levels are the result of activities associated with the bulk waste removal from the quarry.

7 GROUNDWATER PROTECTION

7.1 Program Overview

The groundwater monitoring and protection program at the Weldon Spring Site Remedial Action Project (WSSRAP) includes sampling and analysis of water collected from wells at the Weldon Spring Quarry, the Weldon Spring Chemical Plant and raffinate pits, vicinity properties, and from selected springs in the vicinity of the Weldon Spring site. The groundwater protection program is formally defined in two documents: the *Groundwater Protection Program Management Plan* (Ref. 13) and the *Environmental Monitoring Plan for 1993* (Ref. 9).

7.2 Referenced Standards

Two main criteria were used to develop the groundwater monitoring program: (1) the U.S. Environmental Protection Agency (EPA) *Quality Criteria for Drinking Water* (Ref. 34), which protects public groundwater resources, and (2) the *Missouri Drinking Water Standards* (Ref. 35). These standards are mainly used for comparison of levels observed in the St. Charles County well field. Table 7-1 identifies EPA water quality standards and Missouri Drinking Water Standards for contaminants that are routinely monitored in the groundwater program. Maximum contaminant levels (MCLs) and other drinking water standards are used only as references by the WSSRAP. The affected groundwater does not represent a public drinking water supply as defined in 40 CFR, Section 141.1, Subpart A.

Groundwater is also monitored under the requirements of Department of Energy Order 5400.5, *Radiation Protection of the Public and the Environment*, which designates derived concentration guidelines (DCGs) for ingestion of water equivalent to 100 mrem, based on the consumption of 730 liters/year (Table 7-2).

As specified in Department of Energy Order 5400.5, liquid effluent from U.S. Department of Energy (DOE) activities may not cause private or public drinking waters to exceed the radiological limit of an effective dose equivalent greater than 4 mrem per year or 4% of the DCG.

Upgradient-downgradient water quality comparisons are not possible for the chemical plant site because it sits atop a local groundwater high and straddles the regional groundwater

TABLE 7-1 Referenced Water Standards

Parameter		Level	Reference Standard	Parameter		Level	Reference Standard
Radiochemical	Uranium total[a]	20 µg/l (13.6 pCi/l)	EPA	Metals	$Cu^{(d)}$	1.0 mg/l	MDWS
	Gross α adjusted	15 pCi/l	MDWS		$Fe^{(d)}$	300 µg/l	MDWS
	Ra-226[b]	5 pCi/l	MDWS		Pb	50 µg/l	MDWS
	Ra-228[b]	5 pCi/l	MDWS		$Mn^{(d)}$	50 µg/l	MDWS
	Rn-222	300 pCi/l	EPA		Hg	2.0 µg/l	MDWS
Misc.	2,4-DNT	0.11 µg/l	MDWS		Ni	100 µg/l	MDWS
	TSD	500 mg/l	MDWS		Se	10 µg/l	MDWS
Metals	Sb	6.0 µg/l	MDWS		Ag	50 µg/l	MDWS
	$As^{(c)}$	50 µg/l	MDWS		$Zn^{(d)}$	5.0 mg/l	MDWS
	$Ba^{(c)}$	1.0 mg/l	MDWS	Anions	$Cl^{-(d)}$	250 mg/l	MDWS
	Be	4.0 µg/l	MDWS		F^{-}	2.2 mg/l	MDWS
	$Cd^{(c)}$	10 µg/l	MDWS		$NO_3^{(c)}$	10 mg/l	MDWS
	$Cr^{(c)}$	50 µg/l	MDWS		$SO_4^{(d)}$	250 mg/l	MDWS

(a) Proposed
(b) Standard for combined Ra-226 and Ra-228
(c) Primary maximum contaminant level
(d) Secondary maximum contaminant level
EPA EPA Drinking Water Standards for Radionuclides
MDWS Missouri Drinking Water Standard

TABLE 7-2 Derived Concentration Guidelines for Discharge Waters

Parameter	Derived Concentration Guideline
Natural Uranium	600 pCi/l
Ra-226	100 pCi/l
Ra-228	100 pCi/l
Th-230	300 pCi/l
Th-232	50 pCi/l

divide (Ref. 49). Background values, which were developed by the U.S. Geological Survey for the shallow aquifer (Ref. 49) are used in lieu of these comparisons.

Background levels for uranium, nitrate, and sulfate at the chemical plant/raffinate pits area have been calculated by the USGS based on averages from uncontaminated wells near the chemical plant and ordnance works (Ref. 49).

7.3 Weldon Spring Chemical Plant

7.3.1 Hydrogeology

The chemical plant and quarry are located in the same general geologic environment but are separated geographically. A generalized stratigraphic and hydrostratigraphic column is presented in Figure 7-1. Differences in specific geological features that impact groundwater mechanics necessitate separate monitoring programs for the chemical plant and quarry.

The chemical plant and raffinate pit area consists of two major geologic units; unconsolidated surficial material and carbonate bedrock. The unconsolidated surficial materials are clay-rich units, which are generally unsaturated. Thicknesses range from 6.1 m to 15.3 m (20 ft to 50 ft) (Ref. 2).

The aquifer of primary concern beneath the chemical plant, raffinate pits, and vicinity properties lies within the Burlington-Keokuk Limestone (the shallowest bedrock unit). The Burlington-Keokuk Limestone is composed of two different lithologic zones; a shallow weathered zone underlain by an unweathered or competent zone. Numerous fractures and solution voids are present within the weathered portion of this formation. The unweathered or competent portion of the Burlington-Keokuk Limestone is thinly to massively bedded. Fracture densities are significantly less in the unweathered zone than in the weathered zone. Aquifer properties are a function of fracture spacing, solution voids, and preglacial weathering.

All monitoring wells are completed in the Burlington-Keokuk Limestone. Seventy-one percent are screened in or near the upper weathered portions of this formation. The remainder are screened at deeper levels, in the unweathered zone, to assess vertical migration of contaminants. Where possible, monitoring wells within the boundaries of the chemical plant are located close to potential contaminant sources to assess migration into the groundwater system.

SYSTEM	SERIES	STRATIGRAPHIC UNIT	TYPICAL THICKNESS (ft)	LITHOLOGY	HYDROSTRATIGRAPHIC UNIT
QUARTERNARY	HOLOCENE	ALLUVIUM	0.5–4		ALLUVIAL AQUIFER
	PLEISTOCENE	LOESS, GLACIAL TILL, INTERGLACIAL SEDIMENT AND RESIDUUM	15–55		(unsaturated). *
MISSISSIPPIAN	MERAMECIAN	SALEM FORMATION	0–15		(unsaturated) *
		WARSAW FORMATION	60–80		
	OSAGEAN	BURLINGTON-KEOKUK LIMESTONE	100–200		MISSISSIPPIAN-DEVONIAN AQUIFER SYSTEM
		FERN GLEN FORMATION	45–70		
	KINDERHOOKIAN	CHOUTEAU GROUP	20–50		
		BUSHBERG SANDSTONE	5–20		
DEVONIAN	UPPER	LOWER SULPHUR SPRINGS GROUP (UNDIF)	0–2		ORDOVICIAN LEAKY CONFINING UNIT
ORDOVICIAN	CINCINNATIAN	MAQUOKETA SHALE	10–30		
	CHAMPLAINIAN	KIMMSWICK LIMESTONE	70–100		
		DECORAH GROUP	30–60		
		PLATTIN LIMESTONE	100–130		
		JOACHIM DOLOMITE	80–105		
		ST. PETER SANDSTONE	120–150		ORDOVICIAN-CAMBRIAN AQUIFER SYSTEM
	CANADIAN	POWELL DOLOMITE	50–60		
		COTTER DOLOMITE	200–250		
		JEFFERSON CITY DOLOMITE	160–180		
		ROUBIDOUX FORMATION	150–170		
		GASCONADE DOLOMITE	250		
CAMBRIAN	UPPER	EMINENCE DOLOMITE	200		
		POTOSI DOLOMITE	100		

* THESE UNITS ARE BELIEVED TO BE UNSATURATED IN THE WSS VICINITY

GENERAL STRATIGRAPHY AND HYDROSTRATIGRAPHY OF THE WELDON SPRING AREA

FIGURE 7–1

REPORT NO.: DOE/OR/21548–436	EXHIBIT NO.: A/PI/241/1293	
ORIGINATOR: MGL	DRAWN BY: SRS	DATE: 12/20/93

Additional wells are located outside the chemical plant boundary to evaluate movement of contaminants off site (Figure 7-2).

Springs, a common feature in carbonate terrains, are present in the vicinity of the Weldon Spring site. Four springs are known to be impacted by previous chemical plant operations and discharge water containing one or more of the contaminants of concern (Figure 7-3). A fifth spring located near the site in the 5200 Drainage, discharges water containing nitroaromatic compounds and has been included in the monitoring program.

The presence of elevated uranium and nitrate levels at Burgermeister Spring, which is located 1.9 km (1.2 mi) north of the site and is beyond the area of the contaminated wells, indicates that discrete flow paths are present in the vicinity of the site. To address these complex hydrogeologic conditions, both springs and wells are included in the groundwater monitoring program.

7.3.2 Monitoring Program

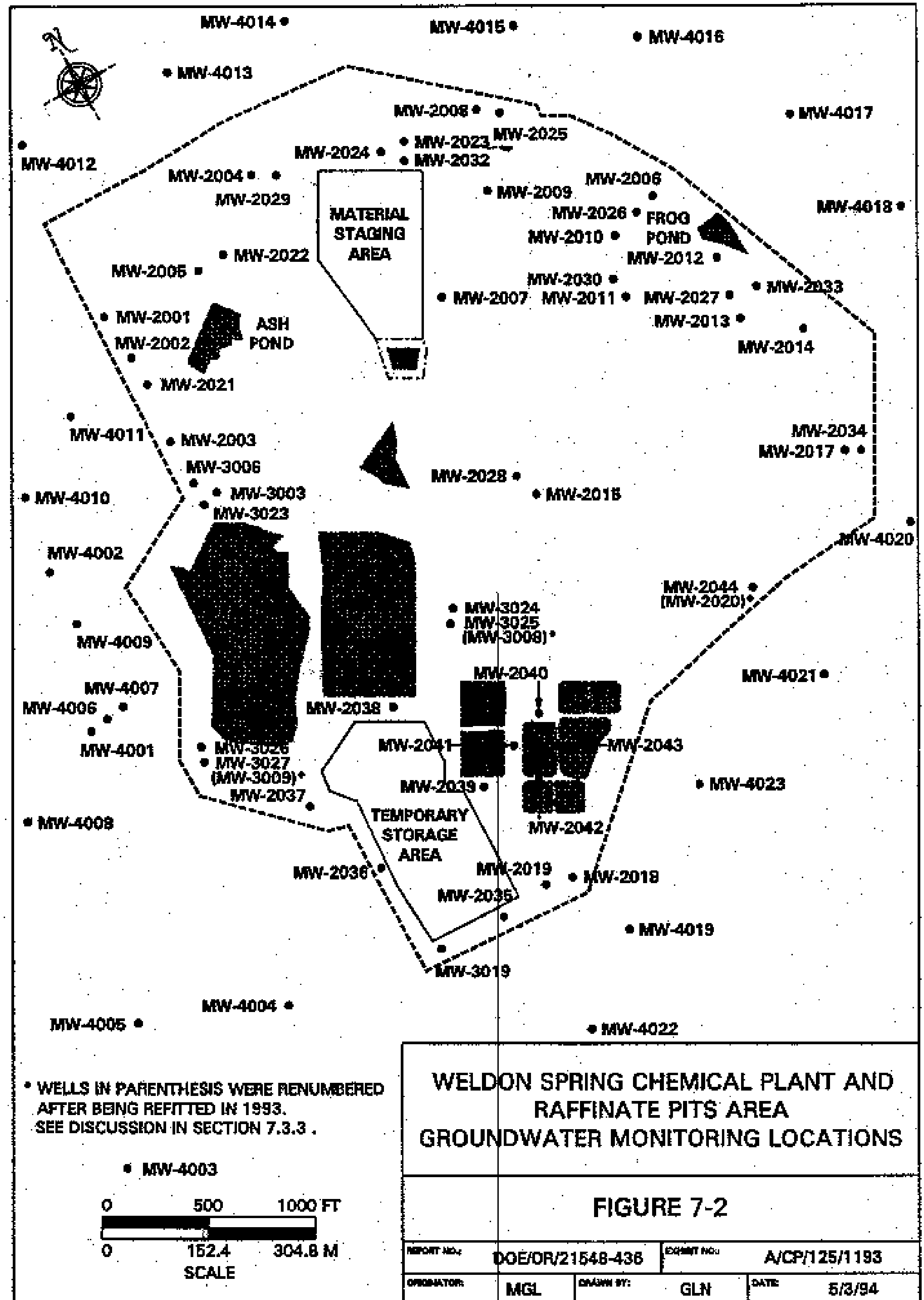
The 1993 groundwater monitoring program at the chemical plant and raffinate pits focused on contaminant monitoring and completing geochemical characterization of on-site groundwater. Total uranium, nitroaromatic compounds, sulfate, and nitrate were monitored either quarterly or semiannually. Locations were sampled semiannually unless the following conditions applied to data collected during 1990-1992:

(1) Less than six samples were collected.

(2) The average total uranium concentration exceeded 13.6 pCi/l.

(3) 2,4-dinitrotoluene (DNT) or 2,6-DNT exceeded 0.11 μg/l or remaining nitroaromatic compounds exceeded 10 times their respective detections limits.

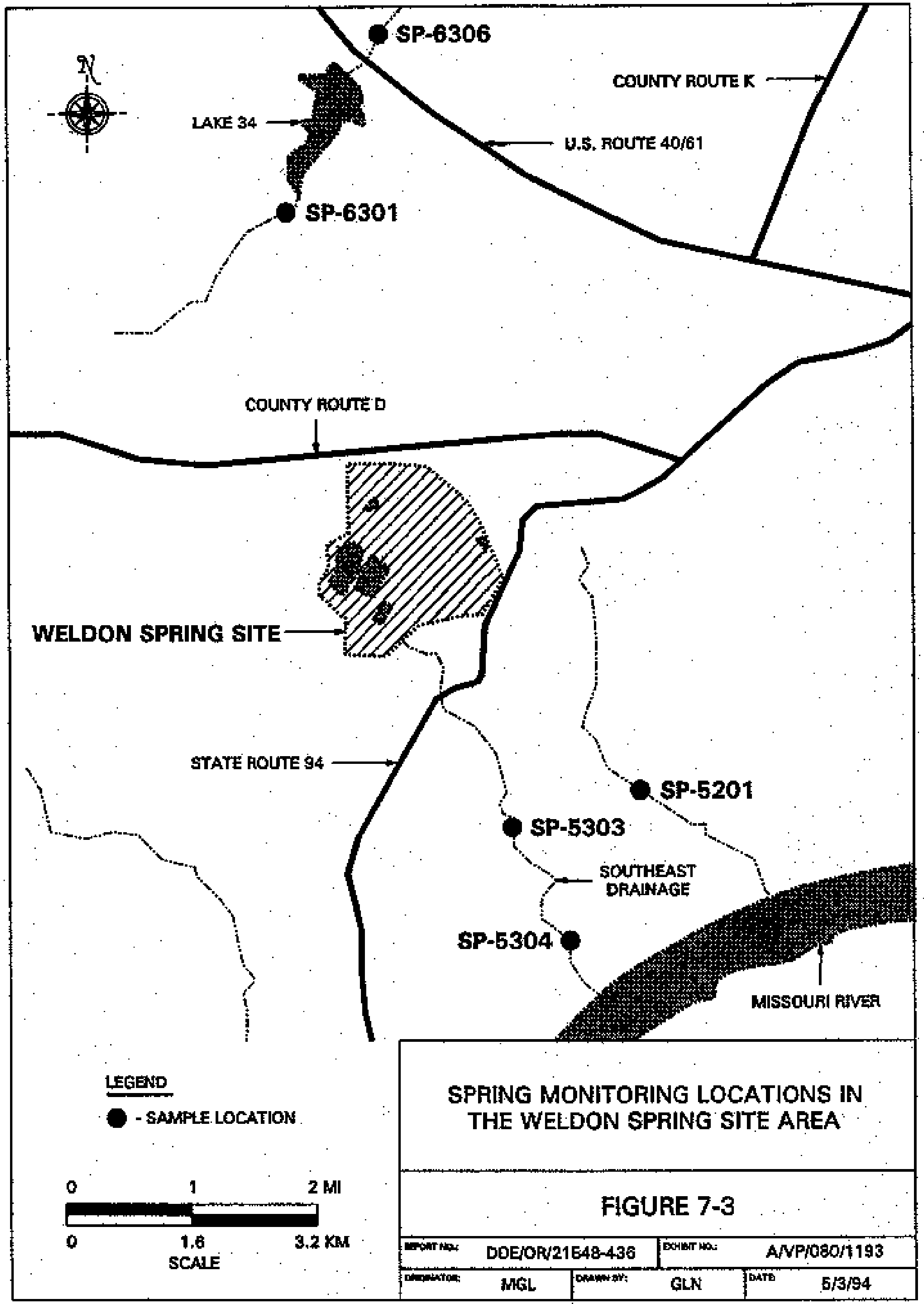
For those locations meeting Condition 1, all parameters were sampled quarterly; for those meeting Conditions 2 or 3, only total uranium or nitroaromatic compounds were sampled on a quarterly basis. If a semiannual well exceeded Condition 2 or 3 during the first sampling event, the location was sampled quarterly for that parameter for the remainder of the year. Monitoring wells around the raffinate pits and chemical plant buildings were sampled annually



WELDON SPRING CHEMICAL PLANT AND RAFFINATE PITS AREA GROUNDWATER MONITORING LOCATIONS

FIGURE 7-2

REPORT NO.:	DOE/OR/21548-436	EXHIBIT NO.:	A/CP/125/1193		
ORIGINATOR:	MGL	DRAWN BY:	GLN	DATE:	5/3/94



SPRING MONITORING LOCATIONS IN THE WELDON SPRING SITE AREA

FIGURE 7-3

for Ra-226, Ra-228, Th-228, Th-230, Th-232, gross alpha, and gross beta. Geochemical sampling, which includes an extensive suite of naturally occurring water quality parameters, was also conducted to provide preoperational characterization data for evaluating the impacts of site remediation on the groundwater, to establish a baseline for the Chemical Plant Groundwater Operable Unit, and to gather sufficient data to support contaminant transport models.

Five springs were sampled quarterly for total uranium, nitrate, sulfate, and geochemical constituents and annually for Ra-226, Ra-228, Th-228, Th-230, and Th-232. With the exception of Burgermeister Spring (SP-6301), the springs are generally monitored at low flow to measure the groundwater component of spring discharge. Burgermeister Spring (SP-6301) was also measured at high flow to evaluate the difference between low flow and high flow, which is dominated by a surface water component.

7.3.3 Chemical Plant and Raffinate Pit Monitoring Results

MONITORING WELLS

In 1993, the measured concentrations for uranium, nitrate, sulfate, and nitroaromatic compounds (the primary contaminants of concern) generally remained within historical ranges at all monitoring wells and springs in the chemical plant area. Although new highs and lows were measured at some locations, these values generally differed from the mean by less than two standard deviations and typically reflected normal variation in the aquifer system rather than significant changes in groundwater conditions. This supposition is further examined with trend analyses in Section 7.3.4.

Data for all parameters analyzed during the 1993 monitoring period are summarized in Appendix A. Poor quality data and outliers that appeared to be unrepresentative of actual conditions at a given location were excluded from the dataset prior to performing the summary calculations. Criteria for removing outliers are discussed in Section 7.3.4. Unabridged datasets have been presented in the *Quarterly Environmental Data Summary for 1993*. The monitoring data for contaminants of concern (uranium, radiological parameters, nitrate, sulfate, and nitroaromatics) are summarized and compared with background levels and water quality standards in the following paragraphs.

RADIOCHEMICAL PARAMETERS

Total uranium, which is measured in all monitoring wells, continues to be present at highest levels near the raffinate pits. In 1993, 21 monitoring wells exceeded the total uranium background level of 2.9 pCi/l (Table 7-3) calculated by the USGS (Ref. 49). Of these, only three locations exceeded the proposed MCL of 20 μg/l (13.6 pCi/l). Only one new total uranium high was measured in 1993 (MW-3003). This new maximum does not represent a significant increase in uranium concentrations. All other radiological parameters were below the water quality standards and DCGs.

TABLE 7-3 Monitoring Wells Exceeding Background Concentrations and/or the MCL for Contaminants of Concern

PARAMETERS						
Uranium[a] >2.9 pCi/l	Nitrate[b] >1.6 mg/l	Sulfate[b] >32 mg/l	2,4-DNT >0.03 μg/l[c]	2,6-DNT >0.01 μg/l[c]	2,4,6-TNT >0.03 μg/l[c]	1,3,5-TNB >0.03 μg/l[c]
2002	2001*	2002	2001*	2001	2008	2001
2017	2002*	2003	2002	2002	2010	200
2019	2003*	2006	2003*	2003	2011	2006
2030	2005*	2008	2005	2005	2012	2008
2032	2006	2009	2006*	2006	2013	2010
2034	2008	2010	2008	2008	2014	2011
2039	2009	2012	2009	2009	2030	2012
2041	2011	2014	2010	2010	2032	2013
3003*	2014	2016	2011	2011	2033	2014
3008	2030	2017*	2012*	2012	3023	2030
3009*	2032*	2019	2013*	2013	4001	2032
3023	2034	2020	2014*	2014	4002	2033
3026	2036	2023	2020	2030	4013	2037
4009	2036	2030	2030*	2032	4014	2038
4010	2037*	2032	2032*	2033		2043
4011	2038*	2034*	2033	2037		3009
4012	2039*	2037	2037*	2038		4001
4016	2040*	2038	2038*	3003		4002
4020*	2041*	2039	2043	3008		4006

TABLE 7-3 Monitoring Wells Exceeding Background Concentrations and/or the MCL for Contaminants of Concern (Continued)

PARAMETERS						
Uranium[a] >2.9 pCi/l	Nitrate[b] >1.6 mg/l	Sulfate[b] >32 mg/l	2,4-DNT >0.03 μg/l[c]	2,6-DNT >0.01 μg/l[c]	2,4,6-TNT >0.03 μg/l[c]	1,3,5-TNB >0.03 μg/l[c]
4021	2042*	2041	3003	3009		4013
4022	2043	3003	3008*	3023		4014
	3003*	3006	3009*	4001		4015
	3008*	3009	3023*	4002		4023
	3009*	3019	4001*	4006		
	3023*	3023*	4002	4013		
	3024*	4001	4006	4014		
	3025*	4003	4013	4015		
	3026*	4011	4015	4023		
	3027*	4012	4023			
	4001*	4013				
	4002	4020				
	4005	4021*				
	4006	4022				
	4011*	4023				
	4013*					
	4014					
	4015					
	4018					
	4021					
	4023					
MCL = 13.6 pCi/l	MCL = 10 mg/l	MCL = 250 mg/l	MCL = 0.11 μg/l	-	-	-

a WSSRAP background uranium concentration
b USGS background concentrations
c Detection limit (DL)
* Monitoring Wells which also exceeded the MCL
NOTE: New well IDs for three monitoring wells MW-3008 is now MW-3024, MW-2020 is now MW-2044, and MW-3009 is now MW-3027. See text in Section 7.3.3 for additional details.

SULFATE AND NITRATE

Sulfate and nitrate were measured at all monitoring wells in the chemical plant area and exceeded the reference levels at some locations. The calculated background value for nitrate (1.6 mg/l) was exceeded at 40 locations (Table 7-3). The drinking water standard (10 mg/l) was exceeded at 22 locations. Above-background sulfate levels (32 mg/l) were measured at 35 locations. Four of these were above the water quality standard (250 mg/l).

NITROAROMATIC COMPOUNDS

Nitroaromatic compounds, which are not naturally occurring compounds, were detected in 30 monitoring wells (Table 7-3). Of these, 14 wells exceeded the ambient water quality standard of 0.11 μg/l for 2,4-DNT.

METALS

Metals were analyzed quarterly or semiannually in all monitoring wells. Although a number of metals have been identified as potential contaminants of concern in the *Remedial Investigation For The Chemical Plant* (Ref. 2), only the following elements were detected at levels exceeding water quality standards: antimony (five locations), cadmium (two locations), chromium (one location), mercury (one location), and nickel (one location). The cadmium values were thought to be associated with analytical problems. Reanalysis of these samples supported this hypothesis: all cadmium values were below 3 μg/l (the limit of detection). Detection limits for antimony were higher than the water quality standard, thus it is not possible to determine the number of wells that may have exceeded this standard. The measured antimony values were close to the limit of detection and are thus subject to large errors.

GROUNDWATER OVERVIEW

Nitrate, sulfate, uranium, and metal contamination is primarily localized in the raffinate pit area. Nitroaromatic contamination is concentrated in four areas (see the 1992 ASER for further discussion on the distribution of contaminants). The impacts of these contaminant levels on site groundwater will be considered under the groundwater operable unit. The major contaminants at the chemical plant (nitrate, sulfate, uranium, and nitroaromatic compounds) will continue to be monitored on a routine basis.

Nine new monitoring wells (MW-2035 through MW-2043) were installed in late 1992 to monitor the effects of the temporary storage area (TSA) and site water treatment plant (SWTP) basin on site groundwater. All of these wells are screened in the shallow weathered zone of the bedrock aquifer. Seven wells (MW-2037 through MW-2043) are located near the raffinate pits and display evidence of contamination from these sources. Raffinate pit signatures are particularly strong in wells MW-2037, MW-2038, MW-2040, and MW-2041, which have some of the highest calcium, sodium, lithium, and nitrate measured on site. The presence of these elements, which are present at high levels in the raffinate pits, is not accompanied by high uranium levels. Only two of these wells were above the calculated background value of 2.9 pCi/l. The highest measured uranium value was 6.9 pCi/l. Relative to the other raffinate pit species, these low levels reflect the high attenuation capacity of site soils for uranium. This was demonstrated experimentally in a series of sorption experiments conducted by the USGS (Ref. 36).

In 1993, two open-hole wells (MW-3008 and MW-3009) were retrofitted to deep wells (MW-3025 and MW-3027, respectively) and new shallow wells (MW-3024 and MW-3026, respectively) were installed next to them. The chemistry of the new wells, which were sampled once in 1993, is similar to the "parent" wells (i.e., the chemistry of MW-3024 and MW-3025 is similar to that of MW-3008). This relationship was expected for the shallow well in the well-pair but not for the deep well. The contamination in the deep wells is possibly the residual effect of downward migration of contaminated water in these open-hole wells. With sufficient time to flush the surrounding aquifer, the chemistry of these deep wells is expected to approach that of other deeper site wells, none of which appear to be contaminated. The four new wells are scheduled for quarterly monitoring in 1994.

SPRINGS

The five springs included in the monitoring program generally remained within historic ranges for all contaminants of concern. The proposed uranium water quality standards were exceeded at SP-5303, SP-5304, SP-6301, and SP-6306. Nitrate exceeded water quality standards at SP-6301, whereas sulfate was below these standards at all locations. Nitroaromatic compounds were detected at SP-5303 and SP-6301 and exceeded the water quality standard for 2,4-DNT at SP-5201.

During 1994, new high values were recorded for two nitroaromatic compounds at SP-5201. Both trinitrobenzene (TNB) values (9.2 μg/l and 4.5 μg/l) were above the previous high of 3.9 μg/l recorded in 1989. TNT was measured at 120 μg/l, which is significantly higher than the previous high of 77 μg/l (measured in 1987). At present, there is insufficient evidence to support a trend, since TNT was measured at 32 μg/l earlier in 1993. The most plausible source for the nitroaromatic compounds is a former Weldon Spring Ordnance Works burning ground, which lies off-site in the 5200 Drainage, and is up gradient of SP-5201.

Springs SP-5303 and SP-5304, both located within the Southeast Drainage, continue to display similar elevated uranium levels. A new low of 57 pCi/l was recorded in a high flow sample collected during the first quarter. This low value is likely the result of dilution from high rainfall. In general, these springs remained within historic ranges during 1994.

The Southeast Drainage springs do not display above-background values for nitrate, sulfate, calcium, lithium, sodium, or strontium, which are all elevated in one or more of the raffinate pits. Thus, these heavily contaminated ponds are an unlikely source of uranium contamination in the Southeast Drainage. The source of uranium is likely residual uranium deposited in the drainage during chemical plant operations, although off-site discharge through NP-0001 and NP-0005 also contributes to this drainage.

A new uranium high was measured for SP-6306, which lies below the outfall of Busch Lake 34. The remaining four uranium samples collected at this location were within previous ranges and were below the MCL (13.6 pCi/l). The cause of the high value, which was an isolated event, is not known.

Burgermeister Spring (SP-6301) recorded a new low value (6.3 pCi/l) in a low-flow sample collected in September. Results for the other contaminants of concern (nitrate, sulfate, and nitroaromatic compounds) were within historic ranges at Burgermeister Spring (SP-6301).

Over the past two years, the WSSRAP has attempted to collect low-flow and high-flow samples from Burgermeister Spring to evaluate the influx of contaminants from groundwater and surface water sources, which is thought to occur during low-flow and high-flow, respectively. Although flow rates from the spring respond to storm events and should be a good indicator of surface water input, alkalinity is perhaps the strongest fingerprint for these two water sources. Surface water alkalinity values are generally low (< 150 mg/l) having a mean value of 89.0 mg/l with a standard deviation of 38.6 mg/l. Groundwater alkalinity values in the local carbonate bedrock are typically higher (>150 mg/l) with a mean value of 344.7 mg/l and a standard deviation of 92.1 mg/l. Using alkalinity as a tracer for surface and groundwater sources, recent data (from late 1991 to the present) indicate that contaminant levels (nitroaromatic compounds, nitrate, and uranium) are generally highest when flow is dominated by groundwater. Alkalinity is not linearly correlated with contaminant levels, however. There are exceptions to this observation however. At present, insufficient alkalinity data exist to determine whether these exceptions are analytical outliers or extremes in the range of natural variation.

7.3.4 Trend Analysis

Trend analysis was conducted for the major contaminants at locations where they have exceeded the detection limit (nitroaromatic compounds) or background levels (nitrate, sulfate, and uranium). Trends were evaluated with the Mann-Kendall test, and slopes were determined with Sen's nonparametric slope estimator. Seasonality was investigated for cases where sufficient data were available using the Mann Whitney U-test.

Outliers were removed from the data set prior to performing statistical analysis. Outliers were examined using the process specified in procedure ES&H 4.9.3, which governs review of environmental monitoring data. The suspect data point is compared with the mean and standard deviation, which have been calculated for the trimmed data set (i.e., the minimum and maximum values have been removed). Data points were removed if they were outside the range defined by the mean, plus or minus four standard deviations, and if natural processes were unlikely to be responsible for the extreme value. An extreme value was not removed if it occurred at the end of the historical record because subsequent data are required to determine if the value represents a change in conditions. Unidentified analytical or sampling errors that are not readily detected in the data validation process are the most plausible sources of the outliers deleted from these analyses.

Outliers, both on the high and low side of the distribution, can seriously impact statistical calculations. Although this is not a severe problem for the nonparametric calculations used for the trend analyses, it is a problem for the Gaussian statistics used to summarize the 1993 monitoring data. Because the objective of both these analyses is to present a representative view of conditions in each well, filtering was performed.

Results

Seasonal influences on contaminant levels were not found at any location. Thus, adjustments for seasonality were not required and the raw data were used for trend analysis. Trends were analyzed over two different time periods. The first included the entire historical monitoring period (1987-present), and the second only included data from the period 1990-present. Of the 178 cases evaluated, 76 trends (59 downward and 17 upward) were observed in the first or long-period analysis. The second or short-period analysis detected 33 trends (18 downward and 15 upward). Only 15 of the 76 long-term trends were also present in the short-term analyses. Many trends in the long-period analysis, especially downward trends in nitrate and nitroaromatic compounds, may be artifacts of changes in analytical techniques and/or laboratories in 1989-1990. Because the 1990-trends are considered more reliable and better reflect recent conditions at the chemical plant site, they are the focus of the following discussions. These short period analyses are summarized in Table 7-4. Trends are identified along with the slope of the trend (predicted change per year), the 1993 mean value for the contaminant, and the predicted change in concentration (in percent) over a one year period. The predicted change is calculated by dividing the slope by the mean and multiplying by 100. The resultant value may not reflect recent change or reliably predict future change, because the slope was calculated over a four year period. The 1993 mean and predicted change are given as an aid to understanding the significance of a trend.

Nitroaromatic compounds: In general, locations exhibiting nitroaromatic trends were randomly distributed across the monitoring area. Typically, only one nitroaromatic compound displayed a trend at a single location. With the exception of 2,6-DNT, trends were not strongly biased in any direction and were primarily restricted to cases with relatively low concentrations. With four exceptions, the 1993 average concentration was < 1 ppb for nitroaromatic compounds that displayed trends.

MW-2013 is a notable exception; significant decreases in trinitrotoluene (TNT), 2,4-DNT, and 2,6-DNT have occurred in this well. Over the 1987-present period, concentrations for these compounds have dropped from tens to hundreds of ppbs to near or less than 1 pbb. Such a dramatic change has not been observed in any other well and may reflect exhaustion of a small source area located near this well. A strong downward trend was also calculated for 2,4-DNT in MW-4001 on the Army property west of the chemical plant site. It is unclear, however, whether this is a long-range trend or a temporary decline, because the

Table 7-4 Trend Analysis Summary for the Chemical Plant and Raffinate Pit Groundwater

	Parameter (Units) # of Cases Evaluated	Location	Slope of Trend in Units/Year	1993 Mean	Predicted Change (%) in One Year*
UPWARD	TNB (µg/l) 20 Cases	2001	0.01	0.05	10
		4015	0.32	1.70	19
	TNT (µg/l) 14 Cases	2014	0.02	0.04	5
		3023	0.02	0.08	26
	2,4-DNT (µg/l) 27 Cases	2001	0.01	0.11	12
		2006	0.04	0.17	24
		2008	0.02	0.09	22
	Nitrate-N (mg/l) 34 Cases	2001	6.33	53.90	12
		2034	0.89	2.50	41
		4011	13.60	55.80	24
	Sulfate (mg/l) 27 Cases	2008	2.43	38.50	6
		2030	5.30	47.40	11
		3008	14.45	88.00	17
		4011	8.48	62.70	14
		4020	9.00	139.00	6
DOWNWARD	TNT (µg/l) 14 Cases	2013	-0.43	0.08	548
		4013	-0.01	0.05	18
	2,4-DNT (µg/l) 27 Cases	2013	-0.12	0.39	31
		4001	-1.40	1.48	96
	2,6-DNT (µg/l) 27 Cases	2009	-0.07	0.19	37
		2010	-0.12	0.52	23
		2011	-0.23	1.60	15
		2013	-8.00	1.20	667
		2014	-0.17	0.56	29
		4006	-0.58	2.85	20
		4013	-0.26	0.78	33
		4015	-0.51	0.31	165

Table 7-4 Trend Analysis Summary for the Chemical Plant and Raffinate Pit Groundwater (Continued)

	Parameter (Units) # of Cases Evaluated	Location	Slope of Trend in Units/Year	1993 Mean	Predicted Change (%) in One Year*
DOWNWARD	Sulfate (mg/l) 27 Cases	2020	-7.00	126.00	6
		3023	-33.00	312.00	11
		4022	-7.37	33.40	22
	Uranium (pCi/l) 29 Cases	2020	-1.26	1.97	64
		3009	-0.46	3.13	15
		4012	-0.57	5.15	11

* These numbers are derived from the statistics (slope/mean) and may not reflect present conditions.

1987-present analysis did not detect a 2,4-DNT trend. Additional monitoring is required to resolve this issue.

Trend data suggest that significant changes in nitroaromatic levels have not occurred at most locations. The bias toward decreasing trends for 2,6-DNT may be related to the ability of this compound to sorb onto site soils. Research by Fink (Ref. 50) showed that among the major nitroaromatic species, 2,6-DNT had the lowest sorption coefficient for the major soil units beneath the chemical plant. If this research is applicable to natural conditions and if soil sorption is a major control on concentration levels, 2,6-DNT should be the first nitroaromatic compound to be flushed from the system. Based on these assumptions, a downward 2,6-DNT trend may be a precursor to future downward trends in other nitroaromatic species. At present, this hypothesis is highly speculative.

Uranium: Uranium levels remained relatively constant during the entire historical period (1987-present). Only three downward trends were observed over the short period (1990-present), and only one (MW-2020) represented a significant change in concentration levels. Ten downward and two upward trends were calculated for the long-period analysis; however, most of these were quite weak (< 1 pCi/l per year). Three of the 10 downward trends were also observed in the shorter period analysis.

Sulfate and Nitrate: Sulfate and nitrate are conserved elements (i.e., they are not retarded by sorption onto soils) that were used in both the ordnance works and chemical plant processes. High sulfate and nitrate levels are still present in some of the raffinate pits, which are considered an active source of these contaminants in the groundwater.

Sulfate displayed both upward and downward trends. Three upward and two downward trends occurred in wells that were well above the assumed background level of 32 mg/l. All of these wells lie within the general vicinity of the raffinate pits. None of the sulfate trends represented significant changes in sulfate levels, however.

Upward nitrate trends were observed in three of the 34 cases analyzed. One of these (MW-2034) occurred in a well near the assumed background level of 1.6 pCi/l. This well lies some distance from the raffinate pits. A continued rise in nitrate levels at this location may indicate the area impacted by seepage from the raffinate pits is gradually increasing to the southeast. At present, however, there is insufficient evidence to support such a conclusion.

Both MW-2001 and MW-4011, the other two wells displaying upward trends, have nitrate levels that are well above the MCLs. Both wells lie downgradient of the raffinate pits and have elevated levels of other compounds that are concentrated in the raffinate pits. Monitoring wells upgradient of these wells but downgradient of the raffinate pits have even higher nitrate concentrations. The upward trends in these two wells, especially MW-4011, which also displays an upward sulfate trend, may indicate the area impacted by seepage from the raffinate pits has been gradually increasing northward.

7.3.5 Summary

Trend analyses of contaminant levels in monitoring wells at the chemical plant site and surrounding properties indicate that conditions have generally remained stable over the 1987-present monitoring period. An exception was the evidence supporting a possible northward increase in the areal extent of groundwater impacted by seepage from the raffinate pits. For the most part, the observed trends (less than 20% of the cases analyzed) were not steep and did not occur at locations with the highest contaminant levels. A notable exception was the sharp decline in nitroaromatic levels in MW-2013.

Contaminant levels in the deeper monitoring wells continued to remain near background levels (nitrate, sulfate, and uranium) or below detection limits (nitroaromatic compounds). In addition, a Missouri Department of Health survey of shallow and deep private water wells in the vicinity of the chemical plant found no evidence of site-derived contamination (Appendix C). These data suggest that groundwater impacted by contaminants from the chemical plant site continues to be located in the upper portion of the shallow aquifer and to be confined to a limited area.

The absence of significant changes over the 7 year monitoring period suggests that the groundwater system is at a steady state condition or is changing too gradually to detect in this time frame. The consistency of the system suggests that flux of contaminated seepage into the groundwater is balanced by that of uncontaminated groundwater resulting in a relatively consistent dilution factor over this period.

7.3.6 Groundwater Summary for the Temporary Storage Area and Site Water Treatment Plant

Data for wells that were installed to monitor the TSA and SWTP basins are included in the Appendixes and Table 7-3. Statistical comparison of downgradient-upgradient wells around the SWTP basin proved inconclusive because some downgradient wells are strongly influenced by seepage from the raffinate pits. This approach will be replaced by comparison against baseline data for each monitoring well. A similar approach (comparison against baseline data) will be used for the TSA basin, which is located on a local groundwater high.

Because the TSA and SWTP were constructed above previously contaminated groundwater, a minimum of six data points are necessary to establish baseline (i.e., the range of variability) for pre-existing contaminants in each well. Statistical comparison against baseline data was not performed because collection of the required number of independent data points had not been completed by the end of 1993. Baseline sampling will be completed in 1994 and baseline comparisons will be given in the 1994 ASER.

7.4 Weldon Spring Quarry

7.4.1 Hydrogeology

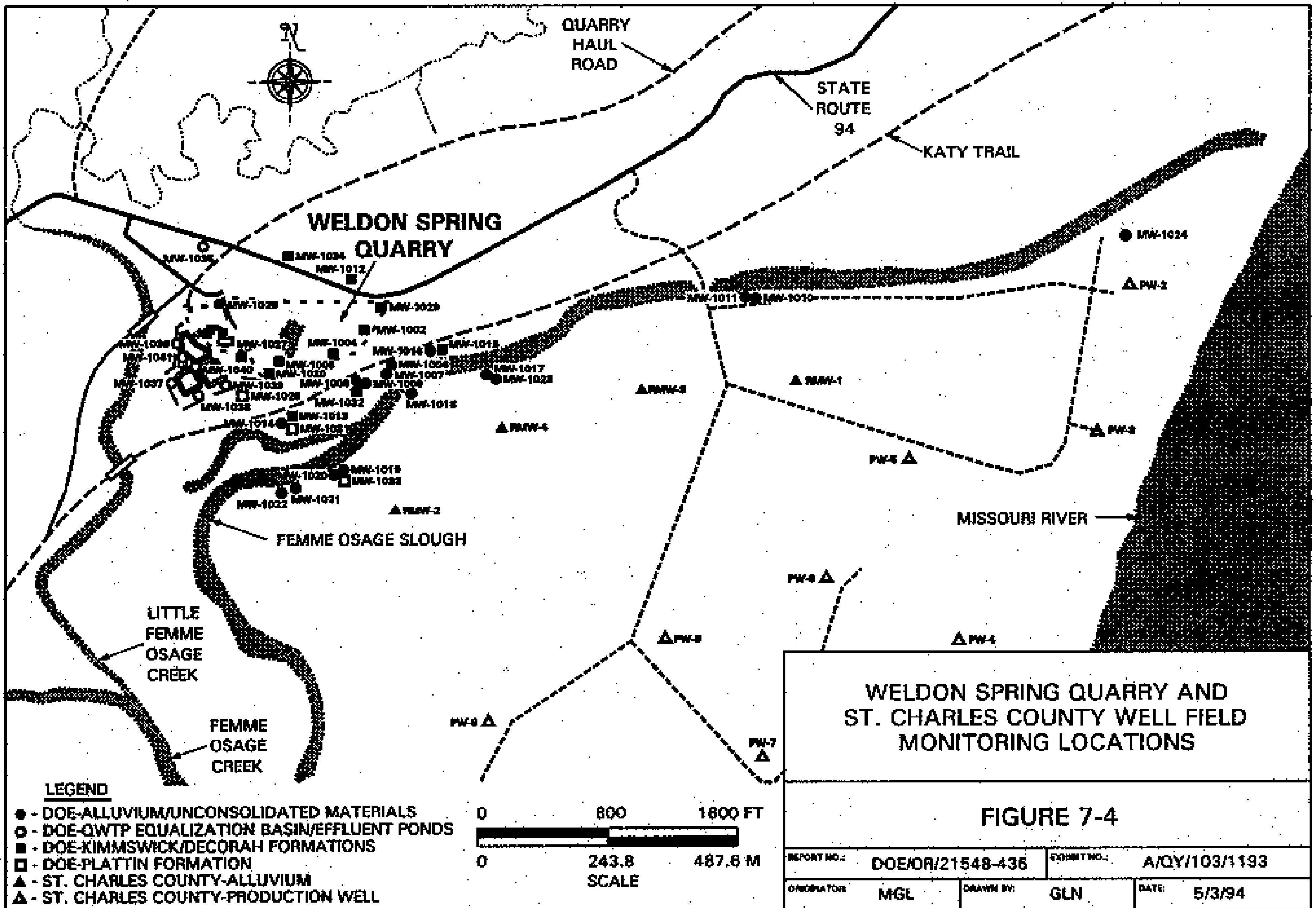
The geology of the quarry area is separated into three units; upland overburden, Missouri River alluvium, and bedrock. The unconsolidated upland material overlying bedrock consists of up to 9.2 m (30 ft) of silty clay soil and loess deposits and is not saturated (Ref. 1). The bedrock at the quarry consists of three distinct Ordovician formations: The Kimmswick Limestone, the limestone and shale of the Decorah Group, and the Plattin Limestone.

The sediment composing the alluvium along the Missouri River coarsens from clays, silts, sands, and gravels at shallower depths to cobbles and boulders above the bedrock. The alluvium thickness increases with distance from the bluff towards the river where the maximum thickness is approximately 31 m (100 ft). The alluvium is truncated at the erosional contact with the Ordovician bedrock bluff (Kimmswick, Decorah, and Plattin formations) composing the rim wall of the quarry. Organic silts and clays with underlying minor amounts of sand are the primary sediments between the bluff and the Femme Osage Slough. An underlying soil layer of silty sand is present below a depth of about 6.1 m (20 ft) in the area of the slough (Ref. 1).

The groundwater flow system at the quarry is composed of alluvial and bedrock aquifers. The alluvial aquifer is predominantly controlled by recharge from the Missouri River and the bedrock aquifer is controlled by precipitation and overland runoff.

At the quarry, 15 DOE monitoring wells are screened within either the Kimmswick-Decorah or Plattin Formations to monitor contaminants near the quarry within the bedrock (Figure 7-4). Twelve monitoring wells were installed to monitor contaminants within the Kimmswick-Decorah Formations comprising and surrounding the quarry. Three other monitoring wells were located south of the quarry within the Plattin Limestone to assess vertical contaminant migration.

There are also 36 monitoring wells screened in the alluvial material between the quarry and the Missouri River. The wells west of the quarry monitor the uppermost water bearing unit below the quarry water treatment plant equalization basin and effluent ponds. The alluvial monitoring wells north of the Femme Osage Slough monitor contaminant migration south of the quarry, while those south of the slough monitor for possible migration of contaminants toward



WELDON SPRING QUARRY AND ST. CHARLES COUNTY WELL FIELD MONITORING LOCATIONS

FIGURE 7-4

the well field. The St. Charles County wells would provide an early warning of contaminant migration toward the county production well field if this were to occur. The county production wells are monitored to verify the quality of the municipal well field water supply.

Monitoring wells MW-1034 (Kimmswick-Decorah) and MW-1035 (alluvium) have been determined to be upgradient of the quarry for the assessment of groundwater quality in these materials and provide background data. In 1992, eight groundwater monitoring wells were installed in the Darst Bottom area approximately 1.6 km (1 mi) southwest of the St. Charles County Well Field by the U.S. Geological Survey to study the upgradient characteristics of the Missouri River alluvium in the vicinity of the quarry. These wells provide a reference for background values in the well field area. A summary of the background values utilized at the quarry is provided in Table 7-5. This table includes the average background values followed by the ranges of values based on two standard deviations about the mean or the average radiological error about the analytical value.

7.4.2 Monitoring Program

Groundwater monitoring is performed in both the alluvial and bedrock aquifers at the quarry (Figure 7-4). Three separate monitoring programs were developed for the quarry in 1993. The first program addresses sampling the Department of Energy wells monitoring the quarry area in order to monitor contaminant migration and the effects of quarry dewatering and bulk waste removal. The monitoring wells adjacent to the quarry and north of the Femme Osage Slough were sampled bimonthly, while monitoring wells located south of the Femme Osage Slough were sampled quarterly. Monitoring wells on the quarry rim were sampled monthly, due to the increased levels of specific parameters over time, to better establish the trend in concentrations at these locations, and to monitor the effects of quarry dewatering activities on the groundwater system.

The second program monitors the St. Charles County well field and the associated water treatment plant. Active production wells, the St. Charles County RMW-series monitoring wells, and untreated and treated water from the water treatment plant were sampled quarterly and annually for selected parameters. This portion of the monitoring program was developed by representatives of the Department of Energy, several State and Federal regulatory agencies, and St. Charles County.

TABLE 7-5 Mean Background Values for Quarry Groundwater Monitoring Locations

Parameter		Kimmswick/ Decorah Formations[a]	Alluvial/ Unconsolidated Materials[b]	Missouri River Alluvium[c]
Total Uranium (pCi/l)	Mean	1.73	0.79	2.01
	95% C.I.*	1.32; 2.15	0.31; 1.27	3.21; 7.23
Radium-226 (pCi/l)	Mean	0.20 ± 0.34**	0.35 ± 0.36**	0.70 ± 0.18**
	95% C.I.*	-1.06; 1.46	-2.79; 3.49	0.38; 1.02
Radium-228 (pCi/l)	Mean	0.70 ± 0.97**	0.52 ± 1.03**	2.2 ± 2.8**
	95% C.I.*	-5.68; 7.08	-2.36; 3.40	-1.40; 5.80
Thorium-228 (pCi/l)	Mean	0.29 ± 0.46**	0.05 ± 0.46**	0.13 ± 0.22**
	95% C.I.*	-2.13; 2.71	-0.58; 0.68	0.06; 0.20
Thorium-230 (pCi/l)	Mean	1.04 ± 0.58**	0.05 ± 0.42**	0.13 ± 0.18**
	95% C.I.*	-8.30; 10.38	-0.58; 0.68	0.04; 0.22
Thorium-232 (pCi/l)	Mean	0.29 ± 0.41**	0.05 ± 0.42**	0.10 ± 0.28**
	95% C.I.*	-2.13; 2.71	-0.58; 0.68	0.10
Gross α (pCi/l)	Mean	6.75 ± 3.43**	0.1 ± 3.5**	3.1 ± 1.98**
	95% C.I.*	-39.6; 53.2	-38.0; 38.2	-0.03; 6.23
Gross ß (pCi/l)	Mean	5.76 ± 2.53**	9.95 ± 4.19**	6.8 ± 1.06**
	95% C.I.*	5.31; 6.21	Only 1 sample	5.27; 8.33
Nitroaromatic Compounds	Mean	No detects	No detects	Not analyzed
Arsenic (µg/l)	Mean	1.42	1.53	3.72
	95% C.I.*	0.64; 2.20	0.51; 2.55	0.05; 7.39
Barium (µg/l)	Mean	150.4	224.8	456.6
	95% C.I.*	140.98; 159.82	205.1; 244.5	365.2; 548.0
Nitrate (mg/l)	Mean	1.01	0.12	0.39
	95% C.I.*	0.46; 1.56	0.119; 0.121	0.12; 0.66
Sulfate (mg/l)	Mean	84.4	39.2	35.2
	95% C.I.*	68.7; 100.1	33.9; 44.5	21.8; 48.6

a MW-1034 (DOE)
b MW-1035 (DOE)
c Darst Bottom Wells (USGS)

* 95% Confidence interval about the mean
** Average radiological error

The third program monitors the equalization basin and the two effluent ponds at the quarry water treatment plant (Figure 7-4). Monitoring wells MW-1035 through MW-1039 were sampled quarterly and annually for selected parameters. The monitoring program was developed to meet the requirements of 40 CFR Part 264, Subpart F and 10 CSR Part 25.7, which require the monitoring of contaminants of concern in the groundwater beneath storage facilities. The contaminants of concern were derived from the *Engineering Evaluation/ Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (Ref. 37) and the *Baseline Risk Evaluation for Exposure to Bulk Waste at the Weldon Spring Quarry, Weldon Spring, Missouri* (Ref. 38). This is discussed in Section 7.4.6.

The groundwater monitoring program at the quarry was dramatically impacted due to the flooding of the St. Charles County Well Field by the Missouri River on two separate occasions. Unusually heavy rains during the spring caused the flooding of the Femme Osage Slough. This heavy precipitation continued through the summer, which resulted in the inundation of the well field in July and September. The highest water level was 145.5 m (477.3 ft) above mean sea level. The typical water level of the Missouri River near the quarry is 136.5 m (448 ft). During the two events, the well field was under an average of 5.2 m (17 ft) of water for a sustained period of time. During the inundation of the well field, 26 monitoring locations, including the 4 RMW-series wells, were unable to be sampled during some period of the third and fourth quarters. Four of the county's production wells were flooded and were not returned to service in 1993. The four remaining production wells were sampled, and the results indicated no detectable levels of total uranium. Activities to clean and redevelop the flooded monitoring wells were delayed during the fourth quarter due to standing water and continued rain.

7.4.3 Quarry Monitoring Results

The results of the 1993 groundwater monitoring program are listed in Appendix A.

<u>Radiochemical Parameters</u>

All groundwater monitoring wells at the quarry were sampled for the following radiochemical parameters: total uranium, Ra-226, Ra-228, Th-228, Th-230, Th-232, gross alpha, and gross beta. The uranium values continue to indicate that the highest levels above background occur in the bedrock down gradient from the quarry and in the alluvial materials north of the Femme Osage Slough. The annual averages for the locations which exceed background are summarized in Table 7-6. The annual averages for the monitoring locations south of the Femme Osage Slough and the St. Charles County well field remain at or below background.

The proposed U.S. Environmental Protection Agency uranium drinking water standard of 20 μg/l (13.6 pCi/l) was exceeded at 13 locations (MW-1004 through MW-1009, MW-1013 through MW-1016, MW-1027, and MW-1030 through MW-1032) during 1993. All of these monitoring wells are located north of the Femme Osage Slough. The DCG for total uranium in discharge water, 600 pCi/l, was exceeded at eight of the above locations; however, these wells are not directly used as drinking water sources. No production wells exceeded the DCG of 24 pCi/l (4% of the DCG for discharge waters) for total uranium in drinking water systems, or the groundwater standard of 20 μg/l (13.6 pCi/l).

The St. Charles County production wells, the RMW-series wells, and pre-treated (MW-RAWW) and treated water (MW-FINW) from the St. Charles County water treatment plant were also sampled quarterly for gross alpha and gross beta. The annual averages for these locations are within background for the Missouri River alluvium. The remainder of the monitoring locations at the quarry were sampled once in 1993 for gross alpha and gross beta. The results indicated that levels were above background (Table 7-5) in the bedrock down gradient from the quarry and alluvial materials north of the Femme Osage Slough. These annual averages are summarized in Table 7-7.

The Missouri Drinking Water Standard of 5 pCi/l for gross alpha and the MCL of 50 pCi/l for gross beta were not exceeded at any of the St. Charles County production wells. The St. Charles County treatment plant finished waters were in compliance with the gross alpha level of 15 pCi/l as established in 40 CFR 141 and endorsed in Department of Energy Order 5400.5.

Ra-226, Ra-228, and isotopic thorium (Th-228, Th-230, and Th-232) were analyzed once in 1993 at all groundwater monitoring locations at the quarry. Levels of the isotopes Ra-226 and Th-230 were indicated to be above average background values (Table 7-5) at several locations both north and south of the Femme Osage Slough. Levels of the isotope Th-230 were also reported to be above background levels in two production wells. These levels did not exceed action criteria set forth in the *Well Field Contingency Plan* (Ref 51). The annual averages from above average background locations are summarized in Table 7-8.

TABLE 7-6 Annual Averages for Total Uranium (pCi/l) Above Average Background at the Weldon Spring Quarry

Location	Total Uranium	Location	Total Uranium
MW-1004[a]	4603	MW-1015[a]	615
MW-1005[a]	1526	MW-1016	347
MW-1006[a]	2788	MW-1027	532
MW-1007	338	MW-1030	322
MW-1008[a]	3063	MW-1031	21.5
MW-1013[a]	633	MW-1032[a]	1097
MW-1014[a]	770		

a Location exceeds DCG of 600 pCi/l

TABLE 7-7 Annual Averages for Gross α (pCi/l) and Gross β (pCi/l) Exceeding Background at the Weldon Spring Quarry

Location	Gross α	Gross β	Location	Gross α	Gross β
MW-1002	BG	8.6	MW-1015	690	200
MW-1004	4200	1120	MW-1016	270	120
MW-1005	1220	410	MW-1017	BG	13.0
MW-1006	2500	770	MW-1018	5.9	BG
MW-1007	680	230	MW-1019	46.0	13.0
MW-1008	2600	1050	MW-1021	8.5	BG
MW-1009	14.0	BG	MW-1027	630	180
MW-1011	BG	15.0	MW-1030	BG	15.0
MW-1012	27.0	15.0	MW-1031	18.0	8.70
MW-1013	510	220	MW-1032	910	350
MW-1014	610	260	MW-1033	BG	9.00

BG = Background

TABLE 7-8 Monitoring Location and Annual Averages of Isotopic Radionuclides (pCi/l) Above Average Background at the Weldon Spring Quarry

Location	Ra-226	Th-230	Location	Ra-226	Th-230
MW-1009	1.20(±0.9)*	BG	MW-1019	BG	0.80 (0.9)*
MW-1013	0.90(±0.8)*	BG	MW-1022	1.60(±1.0)*	0.50(±0.8)*
MW-1015	1.30(±0.9)*	BG	MW-1023	BG	2.00(±1.1)*
MW-1016	BG	1.60(±1.0)*	MW-1024	BG	0.80(±0.8)*
MW-1017	BG	0.60(±0.8)*	MW-PW02	BG	0.50(±0.6)*
MW-1018	BG	0.80(±0.8)*	MW-PW06	BG	4.5(±1.4)*

BG = Background
* = Rad error

These values, which are above average background, exhibited errors approximately equal to the values reported. Comparison of the net difference between the reported values and background levels, to the net difference in the radiological measurement errors for the reported values and background levels, indicated that several of the values could not be differentiated from background levels and, therefore, are not critical. Also, data obtained from these monitoring wells and the background locations from previous years had higher detection limits,typically greater than 1 pCi/l, which resulted in historic values of no detect. Previous measurements may have been of the same order of magnitude as the data reported in 1993, but may not have been indicated by these higher detection limits.

The comparison of the net differences in values and errors for the locations and background levels indicated that two locations, MW-1023 and MW-PW06, could be differentiated from background levels. The 4.5 pCi/l (± 1.4) Th-230 value in production well PW06 and the 2.0 pCi/l (± 1.1) Th-230 value for MW-1023 are above the average background levels for the Missouri River alluvium. The pretreated and treated water samples from the St. Charles County Water Treatment facility indicated levels below the detection limit (<0.4 pCi/l) indicating there was no impact to the St. Charles County Water Treatment Plant. This value is not considered to be representative of levels in the well field, since the gross alpha and Ra-226 values obtained during the same sampling event for PW06 did not show similar increases. Th-230 is an alpha emitter and is a decay product of the U-238 series, as is Ra-226. Also, it is expected that total uranium would increase initially due to its higher solubility than

Th-230. Uranium and thorium wastes are co-mingled in the quarry and it would be expected that the total uranium front would precede the thorium front in groundwater. Concentrations of this magnitude for Th-230 have not been observed in the quarry rim or north of the Femme Osage Slough where the contaminant plume migration from the quarry bulk wastes is initially observed.

The Missouri Drinking Water Standard of 5 pCi/l for combined Ra-226 and Ra-228 was not exceeded at any of the Department of Energy monitoring wells or at any of the St. Charles County production well locations. No water quality standard has been established for thorium isotopes in drinking waters.

Nitroaromatic Compounds

In 1993, samples from all quarry monitoring wells and St. Charles County production wells were analyzed for nitroaromatic compounds. Fourteen locations yielded detectable concentrations of at least one of the six nitroaromatic compounds analyzed. These monitoring wells are situated in the bedrock downgradient of the quarry or in the alluvial materials north of the Femme Osage Slough. A summary of the annual averages for these locations is provided in Table 7-9.

A detectable concentration of 2,6-DNT (0.57 μg/l) was measured in a sample from monitoring well MW-1033 in January 1993. This level was at the detection limit for 2,6-DNT for the analytical laboratory. The location was resampled in response to this detectable concentration. The sample was submitted to the laboratory normally used to analyze nitroaromatic compounds because this laboratory historically provides consistent data. This laboratory has lower detection limits and indicated no detectable concentration (<0.01 μg/l) of 2,6-DNT in the groundwater from this location. The initial value was believed to be a false positive.

The Missouri water quality standard for 2,4-DNT (0.11 μg/l) was exceeded at six locations. These locations are north of the Femme Osage Slough. No MCLs have been established for the other nitroaromatic compounds in groundwater. The remaining locations south of the slough and the St. Charles County production and monitoring wells indicated no detectable concentrations.

TABLE 7-9 Annual Averages at Monitoring Locations with Detectable Nitroaromatic Compound Results (μg/l) Weldon Spring Quarry

Location	1,3,5-TNB	1,3-DNB	2,4,6-TNT	2,4-DNT	2,6-DNT	Nitrobenzene
MW-1002[a]	1313	0.632	226	0.265	43.2	ND
MW-1004[a]	5.75	ND	13.0	2.3	3.56	ND
MW-1005	ND	ND	ND	<0.110	0.290	ND
MW-1006[a]	57.0	ND	10.4	0.173	1.45	ND
MW-1007	ND	ND	ND	ND	0.012	ND
MW-1008	ND	ND	0.126	ND	0.053	ND
MW-1014	ND	ND	ND	ND	<0.010	ND
MW-1015	43.2	0.242	10.9	0.062	0.395	ND
MW-1016	3.34	ND	0.998	ND	0.071	ND
MW-1027[a]	0.328	ND	25.0	8.63	4.42	ND
MW-1029	<0.118	ND	ND	ND	ND	ND
MW-1030[a]	0.194	ND	2.52	0.154	0.536	ND
MW-1032[a]	5.38	ND	16.6	10.2	3.26	ND
MW-1033	ND	ND	ND	ND	0.193	ND

ND Not Detected
a Location exceeds the water quality standard of 0.11 μg/l for 2,4-DNT

Sulfate

All monitoring wells at the quarry and the St. Charles County production wells were sampled for sulfate. Groundwater analyses in 1993 indicated sulfate levels were elevated in the monitoring wells in the bedrock of the quarry rim and in the alluvial materials north of the Femme Osage Slough. Eleven wells exceeded the average background levels for sulfate. These wells are situated north of the slough with the exception of MW-1018, located south of the slough. The elevated levels in MW-1018 may be the result of migration of the sulfate plume which is centered over the area north of the slough. Elevated levels ranging from 200 mg/l to 500 mg/l are present in the southeast portion of the rim and into the downgradient areas of the materials north of the slough. The levels in MW-1018 are within historic ranges for that location. The annual averages of these wells are summarized in Table 7-10.

TABLE 7-10 Annual Averages at Monitoring Locations with Sulfate Results (mg/l) Above Average Background at the Weldon Spring Quarry

Location	Sulfate	Location	Sulfate
MW-1004	215	MW-1014	99.8
MW-1005	167	MW-1015	186
MW-1006[a]	430	MW-1016	149
MW-1007	118	MW-1018	78.3
MW-1008	245	MW-1032	215
MW-1009	246		

(a) Location also exceeds MCL of 250 mg/l

The secondary MCL for sulfate is 250 mg/l; this standard was exceeded at one location, MW-1006. The sulfate concentrations in the St. Charles County production and monitoring wells remained at or below background ranges.

Metals

The St. Charles County production wells were sampled once in 1993 for cadmium, lead, and mercury. The levels for these metals did not exceed the average background values for the Missouri River Alluvium and all values for these metals were within historic ranges. The annual averages for these locations are summarized in Appendix A.

Arsenic and barium were analyzed during the first part of 1993, but were deleted from the program because no notable impact from the bulk wastes in the quarry can be identified. Historic data had indicated arsenic and barium levels are highest in the groundwater of the alluvial materials south of the slough. The data collected during the first half of 1993 are summarized in Appendix A.

Miscellaneous

The St. Charles County RMW-series monitoring wells, the St. Charles County production wells, untreated and treated waters from the St. Charles County water treatment plant, and

Department of Energy monitoring well MW-1024 were sampled in the first quarter for organic compounds, both volatile and semi-volatile, pesticides, and polychlorinated biphyenyls (PCBs). The results of these analyses indicated no detectable concentrations of these compounds which were attributable to the bulk wastes in the quarry.

First quarter results from the St. Charles County production wells indicated detectable concentrations for the pesticide endosulfan sulfate in wells PW02 and PW03. Pesticides are not known to be present in the wastes in the Weldon Spring Quarry. Subsequent resampling of the two production wells in response to these detectable concentrations indicated no detectable concentrations of the pesticide. The initial false positive may be the result of laboratory error.

A detectable concentration of the semivolatile organic compound bis(2-ethylhexyl) phthalate was indicated in the finished water (FINW) from the St. Charles County treatment plant. This value was not considered to be authentic because the analytical laboratory documentation indicated that it was the result of laboratory contamination.

Geochemical Characterization

A select group of groundwater monitoring wells was selected for geochemical characterization. Wells were selected to provide a broad representation of the different geologic media present at the quarry, which include bedrock (MW-1002, MW-1005, MW-1013, MW-1028, MW-1031, MW-1032, MW-1033, and MW-1034), alluvium (MW-1014, MW-1018, MW-1019, MW-1021, MW-1022, MW-1038, and MW-1039), and Missouri River alluvium (MW-RMW1, MW-RMW2, MW-PW02, and MW-PW09). The geochemical characterization includes an extensive list of anions, cations, and metals that are not routinely monitored by the WSSRAP. The analyses are conducted as part of a 2-year characterization of groundwater in order to evaluate groundwater quality, contaminant migration, and remediation alternatives. A summary of the analyses of the data and conclusions drawn from this multi-year investigation will be provided in the next site environmental report. A summary of the results for this monitoring are presented in Appendix A.

7.4.4 Trend Analysis

Statistical tests for seasonal and time-dependent trends were performed on historical and current data from those groundwater wells that exhibited an upward trend in similar analyses performed for the 1992 annual site environmental report and/or that exhibited an upward trend from the review of the 1993 environmental monitoring data. Trending was performed on total uranium and nitroaromatic data. No significant trends for inorganic anions or metals were identified from previous trend analysis.

Statistical Methods

Analyses from monitoring locations that were tested for trends were required to meet the following several criteria.

- Monitoring location exhibited upward trend in total uranium concentrations as determined from 1992 annual site environmental report.

- Monitoring location exhibited recent upward trend in total uranium and/or nitroaromatic compounds from data obtained from 1993 environmental monitoring program.

- Historic average of total uranium and/or nitroaromatic compound concentrations were greater that five times the detection limit for the respective parameters.

The computer program TREND, developed at Pacific Northwest Laboratory, was used to perform the formal groundwater trend testing. The trend method employed was the nonparametric Mann-Kendall test, which best accounts for the factors of nondetects and missing data. The trend slope estimation was performed using Sen's Nonparametric Slope Estimator method. Seasonality hypothesis testing was conducted using Minitab statistical software in which the Mann-Whitney U-Test method was selected for the determination of seasonality.

The outcome of the statistical analysis indicates the possible influence of seasonal behavior on groundwater quality. Trend analysis indicates the presence of a trend and its direction, upward or downward, and the slope is estimated in concentration units per year. A 95% confidence interval was calculated to indicate the variability in the values about this trend line. These values are to be interpreted as indicators not for the prediction of future concentrations, but for areas which should be more closely monitored in the future.

Uranium Statistical Analysis

Based on the above criteria, 15 of the 36 DOE monitoring locations were selected for seasonality and trend analyses. The 15 monitoring wells are located north of the Femme Osage Slough, with the exception of monitoring well MW-1011 located adjacent to the south bank of the slough. The results of the trend analyses are presented in Table 7-11.

Based on the results of the trend analysis on the uranium data, statistically significant upward trends are present south of the quarry in both alluvial and bedrock monitoring wells. These wells are located along the orientation of the predominant fracture system in the quarry area.

It has been determined that the greatest groundwater contaminant migration is along this pathway. The data from 1993 obtained south of the slough did not fit the criteria required for trend analysis. Seasonality was not indicated to be a factor for the trends in this area.

Table 7-11 also summarizes a comparison of the 1992 and 1993 trend analyses. The difference between the two data sets is the inclusion of the 1993 environmental monitoring data in the trend analysis for this year. Upward trends were no longer indicted for the bedrock rim monitoring wells MW-1004 and MW-1005 and bedrock monitoring well MW-1015. This pause in upward trends may be the effect of the flooding of the Missouri River, or the dewatering activities of the quarry on the groundwater environment. Monitoring locations MW-1013 and MW-1031, bedrock monitoring wells located southwest of the quarry, indicated downward trends in total uranium.

Nitroaromatic Compound Statistical Analysis

Trending analysis was performed in 1992 for the nitroaromatic data at the quarry. Nine of 36 DOE monitoring locations were selected for trend analysis in a similar manner as total uranium trend analysis. The summary of the nitroaromatic trend analysis is presented in Table 7-12. Nitrobenzene was not included in the statistical analysis due to levels consistently being below detection limits during sampling at the quarry.

Based on the results of the trending analysis, upward trends are present in the bedrock of the quarry rim and bedrock monitoring locations southeast of the quarry. These monitoring

TABLE 7-11 Quarry Groundwater Total Uranium Trend Analysis Summary and Comparison for 1993

Well ID	Location	Trend		Slope (pCi/l/yr)		95% Confidence Intervals (pCi/l/yr)	
		1992	1993	1992	1993	1992	1993
MW-1004	Bedrock-rim	Upward	Stationary	435	---	238 - 695	---
MW-1005	Bedrock-rim	Upward	Stationary	274	---	121 - 391	---
MW-1006	Alluvium	Upward	Upward	407	253	-215 - 557	84 - 422
MW-1007	Alluvium	Stationary	Stationary	---	---	---	---
MW-1008	Alluvium	Upward	Upward	910	632	711 - 1108	315 - 939
MW-1009	Alluvium	---	Stationary	---	---	---	---
MW-1011	Alluvium	Stationary	Stationary	---	---	---	---
MW-1013	Bedrock	Stationary	DOWNWARD	---	-35	---	-75 - -2
MW-1014	Alluvium	Stationary	Stationary	---	---	---	---
MW-1015	Bedrock	Upward	Stationary	215	---	68 - 306	---
MW-1016	Alluvium	Upward	Upward	132	53	58 - 224	25 - 93
MW-1027	Bedrock-rim	Stationary	Stationary	---	---	---	---
MW-1030	Bedrock-rim	---	Upward	---	102	---	0.1 - 263
MW-1031	Bedrock	Stationary	DOWNWARD	---	-5.4	---	-11 - -0.9
MW-1032	Bedrock	Upward	Upward	846	348	36 - 1202	28 - 748

TABLE 7-12 Quarry Groundwater Nitroaromatic Compound Trend Analysis Summary and Comparison for 1993

Well ID	Area	Compound	Trend		Slope (µg/l/yr)		95% Confidence Intervals (µg/l/yr)	
			1992	1993	1992	1993	1992	1993
MW-1002	Bedrock-rim	2,4-DNT	Stationary	Upward	—	0.04	—	0.02, 0.07
		2,6-DNT	Upward	Upward	2.7	5.3	1.8, 4.9	3.9, 8.2
		1,3,5-TNB	Upward	Upward	62	233	40, 110	146, 350
		1,3-DNB	Stationary	Upward	—	0.1	—	0.04, 0.2
		2,4,6-TNT	Upward	Upward	10	40	4.9, 17	26, 61
MW-1004	Bedrock-rim	2,4-DNT	Upward	Upward	0.7	0.4	0.6, 0.9	0.1, 0.6
		2,6-DNT	Upward	Stationary	0.8	—	0.4, 1.2	—
		1,3,5-TNB	Upward	Upward	1.2	0.8	0.7, 1.8	0.4, 1.3
		1,3-DNB	Downward	Downward	0.03	0.0	-0.04, 0	-0.03, 0.0
		2,4,6-TNT	Upward	Stationary	0.8	—	0.4, 1.2	—
MW-1006	Alluvium	2,4-DNT	Stationary	Stationary	—	—	—	—
		2,6-DNT	Stationary	Stationary	—	—	—	—
		1,3,5-TNB	Stationary	Stationary	—	—	—	—
		1,3-DNB	Downward	Downward	0.04	-0.03	-0.05, -0.01	-0.04, 0.0
		2,4,6-TNT	Stationary	Stationary	—	—	—	—

TABLE 7-12 Quarry Groundwater Nitroaromatic Compound Trend Analysis Summary and Comparison for 1993 (Continued)

Well ID	Area	Compound	Trend		Slope (µg/l/yr)		95% Confidence Intervals (µg/l/yr)	
			1992	1993	1992	1993	1992	1993
MW-1008	Alluvium	2,4-DNT	---	Downward	---	-0.02	—	-0.02, 0.0
		2,6-DNT	---	Downward	---	-0.04	—	-0.05, -0.01
		1,3,5-TNB	---	Stationary	---	---	—	---
		1,3-DNB	---	Downward	---	-0.03	---	-0.04, -0.01
		2,4,6-TNT	---	Stationary	---	---	---	---
MW-1015	Bedrock	2,4-DNT	Stationary	Stationary	---	---	---	---
		2,6-DNT	Stationary	Stationary	---	---	---	---
		1,3,5-TNB	Upward	Stationary	28	—	6.7, 100	---
		1,3-DNB	Stationary	Stationary	---	—	---	---
		2,4,6-TNT	Stationary	Stationary	---	---	---	---
MW-1016	Alluvium	2,4-DNT	Downward	---	0.01	---	-0.02, 0	—
		2,6-DNT	Stationary	---	---	---	---	---
		1,3,5-TNB	Upward	---	4.5	---	-3.8, 20	---
		1,3-DNB	Downward	---	0.01	---	-0.02, 0	---
		2,4,6-TNT	Stationary	---	---	---	—	---

051994

TABLE 7-12 Quarry Groundwater Nitroaromatic Compound Trend Analysis Summary and Comparison for 1993 (Continued)

Well ID	Area	Compound	Trend		Slope (µg/l/yr)		95% Confidence Intervals (µg/l/yr)	
			1992	1993	1992	1993	1992	1993
MW-1027	Bedrock	2,4-DNT	---	Stationary	---	---	---	---
		2,6-DNT	---	Stationary	---	---	---	---
		1,3,5-TNB	---	Stationary	---	---	---	---
		1,3-DNB	---	Stationary	---	---	---	---
		2,4,6-TNT	---	Stationary	---	---	---	---
MW-1030	Bedrock-rim	2,4-DNT	---	Upward	---	0.03	---	0.01, 0.07
		2,6-DNT	---	Upward	---	0.12	---	0.05, 0.38
		1,3,5-TNB	---	Stationary	---	---	---	---
		1,3-DNB	---	Stationary	---	---	---	---
		2,4,6-TNT	---	Upward	---	0.38	---	0.11, 1.04
MW-1032	Bedrock	2,4-DNT	---	Upward	---	0.08	---	-0.05, 0.21
		2,6-DNT	---	Stationary	---	---	---	---
		1,3,5-TNB	---	Stationary	---	---	---	---
		1,3-DNB	---	Stationary	---	---	---	---
		2,4,6-TNT	---	Stationary	---	---	---	---

--- Not applicable

wells are also located along the orientation of the predominant fracture system. Several monitoring locations were added to this year's trend analysis, but indicated only slight upward trends in two bedrock monitoring locations.

A comparison of the 1992 and 1993 data indicates the greatest upward trends were exhibited in the eastern portion of the quarry rim (MW-1002). This monitoring well is situated in the rim adjacent to the area of greatest volume of nitroaromatic bulk wastes. A large volume of these wastes was removed during the latter half of 1993, which might indicate mobilization of nitroaromatic compounds into the groundwater, due to disturbance and greater infiltration of precipitation in this area.

7.4.5 Groundwater Summary for the Quarry Water Treatment Plant

Monitoring wells MW-1035 through MW-1039 were installed in 1991 to monitor the shallow groundwater in the vicinity of the quarry water treatment plant. These monitoring wells are sampled according to a detection monitoring program as outlined in 40 CFR 264, Subpart F and 10 CSR 25.7, Subpart F. These five wells are monitored for the contaminants of concern as derived from previous evaluations documented in the *Engineering Evaluation\Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry* (Ref. 52) and the *Baseline Risk Evaluation for Exposure to Bulk Waste at the Weldon Spring Quarry, Weldon Spring, Missouri* (Ref. 53).

The concentrations at the compliance points (monitoring wells) were compared with background of the shallow groundwater beneath the treatment plant area or to groundwater protection standards. Statistical analysis of the total uranium, barium, and sulfate data was performed. The non-parametric ANOVA test was used in both the preoperational to background comparisons, and the total data set comparisons to background. The Mann-Whitney U-test was utilized for comparing the preoperational and operational data for each monitoring location. Analysis for the radiochemical parameters was not performed because insufficient data was available this year for comparison. Nitrate and arsenic were not statistically analyzed due to the data for all five monitoring locations being less than the detection limit. This was also true for the analyses for nitroaromatic hydrocarbons, polychlorinated biphenyls, polynuclear aromatic hydrocarbons, and pesticides.

Monitoring well MW-1035 has been determined to be hydraulically upgradient for the determination of the quality of the shallow groundwater in the alluvial/unconsolidated materials where the quarry water treatment plant is located. A summary of the background values is given in Table 7-13. This table includes the average background values followed by the ranges of values based on two standard deviations about the mean or the average radiological error about the analytical value.

The results of the non-parametric ANOVA test indicated that there is statistically significant evidence of differences between the preoperational data for total uranium, barium, and sulfate among the monitoring locations. Statistical analysis indicated that during the preoperational period, several of the compliance monitoring locations had higher concentrations than background levels for total uranium, barium, and sulfate. This would indicate that comparing these locations to background during the compliance period would not indicate contamination from the waste management unit. A summary of the statistical analysis is given in Table 7-14. The only change in conditions when the compliance points were compared to background was observed in monitoring location MW-1039, which indicated that the sulfate concentrations after treatment plant operations start had statistically increased above background levels. The difference between the critical difference for the background location and the computed difference between the average ranks for monitoring location MW-1039 was less than 1, which would indicate that the difference is small.

The results of the comparison of preoperational to operational data using the Mann-Whitney U-test indicated that the operational sulfate values for MW-1037 were greater than the preoperational sulfate values. This well is located closest to the Little Femme Osage Creek and the static water level in this monitoring well responded to the flooding of the Little Femme Osage Creek by the Missouri River during the summer and fall of 1993, indicating that the creek was influencing the groundwater in that area. Sulfate levels in the river are moderately higher (mean = 113 mg/l; $\sigma = 40$) than that in the groundwater, which may be the cause for the higher sulfate concentrations in MW-1037 during 1993.

The Mann-Whitney U-test performed using the total uranium data indicated that the operational data for monitoring well MW-1038 was slightly higher than the preoperational data, and the preoperational data for monitoring well MW-1039 was higher than operational data. The median values for each parameter for the preoperational and operational data at these locations are within 0.9 pCi/l of each other and are considered negligible. These values are within

TABLE 7-13 Mean and Median Values for Background Monitoring Well (MW-1035) at the Quarry Water Treatment Plant

Parameter	Background Mean	Background Median	Parameter	Background Mean	Background Median
Total Uranium (pCi/l)	0.79 (-0.89; 2.47)	0.35	Gross ß (pCi/l)	5.9 (±2.5)	*
Ra-226 (pCi/l)	0.35 (0.21; 0.49)	0.35	Nitroaromatic Compounds	No detects	**
Ra-228 (pCi/l)	<0.23 (-0.41; 0.86)	0.23	Arsenic (µg/l)	<1.5 (-1.5; 4.6)	1.0
Th-228 (pCi/l)	<0.1 (0.01; 0.28)	0.15	Barium (µg/l)	224.8 (166.0; 283.6)	223.0
Th-230 (pCi/l)	<0.1 (0.01; 0.28)	0.15	Nitrate (mg/l)	0.12 (-0.04; 0.27)	0.12
Th-232 (pCi/l)	<0.1 (0.01; 0.29)	0.15	Sulfate (mg/l)	41.0 (23.65; 58.3)	38.7
Gross α (pCi/l)	<0.2 (±3.5)	*	Alkalinity (mg/l)	226.9 (171.5; 282.4)	220

* Insufficient data to determine median value

** No detectable concentrations

TABLE 7-14 Summary of Comparison of Monitoring Locations to Background

Monitoring Well	Total Uranium		Barium		Sulfate	
	Pre-op	Operational	Pre-op	Operational	Pre-op	Operational
MW-1036	> BG	> BG	> BG	> BG	> BG	> BG
MW-1037	< BG	< BG	> BG	> BG	< BG	< BG
MW-1038	> BG	> BG	< BG	< BG	< BG	< BG
MW-1039	> BG	< BG	> BG	> BG	< BG	> BG

> BG Greater than background (as established in MW-1035)

< BG Less than background (as established in MW-1035)

background ranges for total uranium. Monitoring wells MW-1038 and MW-1039 are located approximately 60 m (200 ft) from the edge of the equalization basin.

Based on groundwater gradient maps, two monitoring wells (MW-1040 and MW-1041) were installed in late 1993 within 7.5 m (25 ft) of the equalization basin to better monitor the equalization basin area. No data were available in 1993 for these two locations. Monitoring wells MW-1038 and MW-1039 will not be included in the waste facility monitoring program based on the groundwater flow direction. Monitoring wells MW-1038 and MW-1039 are hydraulically cross-gradient from the equalization basin in a porous medium aquifer and the results from these wells do not monitor possible contamination from the basin.

7.5 Well Abandonment

In 1993, no groundwater monitoring wells were abandoned at the chemical plant or the quarry.

7.6 Highlights

- Contaminant levels generally remained within historic ranges at all chemical plant locations. A new uranium high was measured at one off-site location, but subsequent uranium measurements were within historic range.

- Monitoring results for groundwater and springs were generally within background ranges. Although some new highs and lows were recorded, they generally did not represent significant changes.

- Analysis for seasonal and temporal trends indicated that seasonal factors were not strongly related to contaminant levels and that conditions were stationary in over 80% of the cases analyzed for temporal trends. Notable exceptions were the steep downward trends for nitroaromatics in MW-2013 and the increasing nitrate levels in two wells north of the raffinate pits.

- Examination of the relationship between alkalinity and contaminant levels suggests that contaminant levels are typically higher when the groundwater component dominates flow at Burgermeister Spring.

- Analysis for temporal trends indicated downward trends were indicated in two monitoring wells at the quarry (MW-1013 and MW-1014) which previously indicated stationary total uranium levels. No new upward trends were indicated for total uranium in the wells statistically analyzed. Downward trends in nitroaromatic compounds were also indicated in one or more of the six parameters at three groundwater monitoring locations (MW-1004, MW-1006, and MW-1008) statistically analyzed. Upward trend in some or all of the six parameters were maintained at two quarry rim locations (MW-1002 and MW-1004).

- Flooding of the St. Charles County Well Field by the Missouri River inundated 26 groundwater monitoring locations; therefore, some of these wells were not sampled during the third and fourth quarters of 1993. Later sampling indicated that the St. Charles County production wells were not impacted by contaminants migrating from the bulk wastes in the quarry during the flooding.

- Environmental monitoring indicates that the largest amount of contamination is still present in the bedrock of the quarry rim and the alluvial materials and bedrock north of the Femme Osage Slough. Total uranium concentrations remain within background levels, and no detectable concentrations of nitroaromatic compound were identified south of the slough or in any of the St. Charles County production wells.

- Statistical analysis of the data obtained from the monitoring system around the quarry water treatment plant indicated that during the preoperational period several of the compliance monitoring locations had higher concentrations than background levels for total uranium, barium, and sulfate. A comparison of these locations to background levels would not indicate contamination. Results also indicated that one monitoring location had an increase in sulfate after operations at the plant started. The groundwater at this location was impacted by floodwater resulting in the elevated levels. Another monitoring location also indicated higher total uranium concentrations after operation of the facility. The difference between the preoperational and operational data is considered to be insignificant and within the background ranges for total uranium in the area.

8 BIOLOGICAL MONITORING PROGRAM

8.1 Program Description

The biological monitoring program complies with the regulatory requirements included in the U.S. Department of Energy (DOE) Orders, the *National Environmental Policy Act* (NEPA), the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA), and other appropriate Federal and State regulations. Many of the sampling activities directed by DOE Orders 5400.1 and 5400.5 such as preoperational monitoring, effluent monitoring, and environmental surveillance are used to support the NEPA and CERCLA biological monitoring program and include the collection and analysis of water, soil, foodstuffs, and biota.

Activities for the biological monitoring program are selected from the results of pathway analysis. Exposure pathways identified for human and ecological receptors are identified in Section 2.1 of the *Environmental Monitoring Plan for Calendar Year 1993* (Ref. 9). Complete pathways are those that show a link between one or more contaminant sources, through one or more environmental transport processes, to a human or ecological exposure point. These exposure pathways are used to direct biological sampling activities and determine the type of data that needs to be gathered, documented, and presented.

Results of biological monitoring also support human dose calculations, as presented in Section 4, by providing data for the human ingestion pathways. The remaining pathways are monitored to support biological risk assessment studies and compliance with environmental surveillance requirements.

8.2 Applicable Standards

DOE Orders and U.S. Environmental Protection Agency (EPA) regulations provide the standards of compliance for the biological monitoring program. A surveillance level has been determined based upon DOE guidelines for established annual effective dose equivalents for humans consuming terrestrial foodstuffs.

DOE Order 5400.5 also addresses the protection of native aquatic organisms from the potential bioaccumulation of radionuclides. The Order states that the absorbed dose shall not exceed 1 rad per day from exposure to the radioactive material in liquid wastes discharged to natural waterways.

The biological monitoring program provides supporting data for the dose estimates in Section 4 on the possible ingestion of biota by humans. These calculations were based on the guideline that members of the public should not be exposed to radiation sources as a consequence of all routine DOE activities in any one year that could cause an effective dose equivalent greater than 100 mrem (1 mSv).

The EPA has established Federal ambient water quality criteria for various pollutants, including a number of metal and nitroaromatic contaminants found at the Weldon Spring site. The EPA criteria are used in developing surveillance levels for fish and also serve as a guide in the surveillance of benthic invertebrates, waterfowl, and zooplankton.

8.3 Monitoring Results

The biological monitoring program was divided into two study units: aquatic and terrestrial. Studies were conducted as detailed in the *Environmental Monitoring Plan for Calendar Year 1993* (Ref. 9) with any deviations discussed below in the appropriate sections. General study locations can be found on Figure 1-4.

8.3.1 Aquatic Monitoring

Biota are primarily exposed to radionuclides and other contaminants of concern at the Weldon Spring site by aquatic pathways. Contaminated surface water bodies and surface water runoff from the site to off-site lakes and streams provide the main route of exposure to biota. Characterization studies have been conducted to determine the effects of contaminants on biota at on-site and off-site properties. The only contaminants of concern for off-site surface water and sediments are uranium, arsenic, lead, and mercury. Biouptake studies conducted on fish were based on human consumption of game species.

8.3.1.1 Fish. In 1993, the Weldon Spring Site Remedial Action Project (WSSRAP) and the Missouri Department of Conservation (MDC), sampled fish from off-site properties, including Lakes 34, 35, and 36 at the Busch Memorial Conservation Area, and the Femme Osage Slough within the Weldon Spring Conservation Area. Elevated levels of uranium are known to exist in these areas. Lake 33 at the Busch Memorial Conservation Area, which has been shown to have no hydraulic connection to the site, was used as a background sampling location.

Samples taken consisted primarily of game species such as large mouth bass, crappie, sunfish, and catfish. Samples were prepared as whole, fillets, and fish cakes (crappie and sunfish only), and were analyzed for total uranium, arsenic, and lead. All data below the detection limit are presented and were used in calculations as half of the detection limit according to EPA guidance (Ref.39) unless uncensored data were available (Section 9.1.5).

Fish samples were once again collected in 1993 to ensure public health and safety. Although review of previous year's fish data indicated that flesh samples from fish residing in Busch Lakes 35 and 36 contained radionuclides at levels significantly higher than background lakes, the concentrations were extremely low and the total dose estimate was less than 1.0 mrem/year. For this reason, the fish sampling for 1993 was reduced from previous years.

The highest uranium concentrations were found in the sunfish cakes from Lake 36 (0.129 pCi/g) and Lake 35 (0.047 pCi/g). Table 8-1 presents the uranium data for the 1993 fish samples. Higher concentrations would be expected in whole and fishcake samples since radionuclides tend to accumulate in the bones and organs. All other samples were less than 0.02 pCi/g. Background concentrations ranged from 0.0001 pCi/g to 0.0007 pCi/g. The data are presented as total uranium with detection limits ranging from 1.35E-05 pCi/g to 9.86E-05 pCi/g.

TABLE 8-1 Average 1993 Uranium and Metal Concentrations in Fish

Location	Sample Type	Total Uranium (pCi/g)	Arsenic (µg/g)	Lead (µg/g)
Lake 33[a]	Sunfish Cakes	0.0007	0.135	0.041
	Bass Fillets	0.0001	0.100	0.340
	Catfish Fillets	0.0001	<0.023	0.110
	Crappie Fillets	0.0001	0.063	0.068
Lake 34	Sunfish Cakes	0.0186	<0.025	0.093
	Bass Fillets	0.0005	0.020	0.050
	Catfish Fillets	0.0007	<0.025	0.110

TABLE 8-1 Average 1993 Uranium and Metal Concentrations in Fish (Continued)

Location	Sample Type	Total Uranium (pCi/g)	Arsenic (μg/g)	Lead (μg/g)
Lake 34	Crappie Cakes	0.0023	<0.023	0.150
Lake 35	Sunfish Cakes	0.0469	<0.020	0.090
	Bass Fillets	0.0003	<0.020	0.084
	Catfish Fillets	0.0044	<0.020	0.032
	Crappie Fillets	0.0007	<0.019	0.320
	Crappie Cakes	0.0077	<0.021	0.140
	Crappie Whole	0.0161	0.065	0.530
Lake 36	Sunfish Fillets	0.0088	<0.021	<0.021
	Sunfish Cakes	0.129	<0.026	0.130
	Bass Fillets	0.0006	0.089	0.035
	Catfish Fillets	0.0014	0.054	0.110
	Crappie Fillets	0.0013	0.039	<0.020
	Crappie Cakes	0.0193	0.026	<0.023
Femme Osage Slough	Bass Fillets	0.0002	0.085	0.030
	Carp Fillets	0.0019	0.057	0.140
	Crappie Cakes	0.0046	<0.022	0.026

* Background lake

Arsenic and lead were also analyzed as part of the 1993 fish monitoring program. Results are presented in Table 8-1. Arsenic was detected in 11 of the 23 samples collected. Arsenic concentrations in fish ranged from <0.023 μg/g to 0.135 μg/g in the background lakes. Concentrations in the study lakes ranged from <0.019 μg/g to 0.089 μg/g. The highest concentration in the study lakes (0.089 μg/g) was found in the bass fillet sample from Lake 36. Lead was detected in most of the samples taken from both the study lakes and background lakes. Lead values ranged from <0.020 μg/g to 0.340 μg/g in the background lake and from <0.020 μg/g to 0.530 μg/g in the study lakes. The highest concentration (0.530 μg/g) was found in the whole crappie sample from Lake 35. The highest concentration found in the edible portions was 0.340 μg/g in bass fillets from Lake 33.

8.3.1.2 Benthic Invertebrates and Zooplankton. Benthic invertebrates and zooplankton were to be collected in 1993 as part of the aquatic biological screening investigation required by DOE Order 5400.5. The study was not conducted during the 1993 season due to a redefining of sampling requirements, and later, due to flooding which made many of the sampling locations inaccessible. Sampling is scheduled for the 1994 season and will be the same program as that designed for 1993.

8.3.2 Terrestrial Monitoring

Terrestrial monitoring studies focused on sampling agricultural products as required by DOE Order 5400.1.

8.3.2.1 Agricultural. The *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (Ref. 32) and DOE Order 5400.5 require the analysis of "foodstuff" (crops and dairy products) within a 16 km (10 mi) radius of all DOE facilities. Based upon results of the 1991 and 1992 data, a committed effective dose equivalent was calculated at 0.03 mrem/year. This dose was based on an individual consuming 186.6 g (6 oz) of corn once a week over 1 year and using the highest uranium concentration found in corn kernels, 0.111 pCi/g. This dose was less than the annual effective dose of .1 mrem/year. Therefore, based upon DOE guidance for dose from foodstuffs of <1 mrem/year, surveillance sampling instead of annual sampling will be conducted in the future. A surveillance program has been established based upon past data and the committed effective dose equivalent of 0.03 rem/year. The surveillance program uses effluent data to trigger the onset of continued agricultural sampling (i.e., if air monitoring data shows a release of radionuclides above background).

During 1993, samples were collected only from background locations because of significantly higher concentrations of uranium than at study locations, as discussed in the *1993 Environmental Monitoring Plan* (Ref. 9). Although the committed dose equivalent was calculated at 0.03 mrem/year and a surveillance program was established, it was determined that better representative background samples should be collected during 1993. Because of the flooding throughout St. Charles and surrounding counties, only four background samples were collected. Furthermore, the St. Charles County well field could not be sampled during 1993, as the well field was flooded by the Missouri River twice during the summer.

The agricultural samples (three corn and one soybean) were collected from background locations, along with corresponding soil samples, and analyzed for total uranium, Ra-226, Ra-228, Th-228, Th-230, and Th-232. Uranium concentrations ranged from <0.004 pCi/g to 0.006 pCi/g. A summary of the agricultural and soils data can be found in Table 8-2. A surveillance program has been established (*Environmental Monitoring Plan* for 1994) and additional background samples will be collected during 1994.

TABLE 8-2 1993 Average Agricultural Background Radionuclides Concentrations (pCi/g)

Parameter	Corn	Soybeans	Soil
Uranium	0.003	<0.004	1.16
Ra-226	0.028	0.05	1.22
Ra-228	0.037	0.11	1.8
Th-228	<0.008	0.02	0.91
Th-230	0.044	0.04	1.1
Th-232	0.009	<0.008	1.27

8.4 Highlights

- Uranium concentrations ranged from 0.001 pCi/g to 0.129 pCi/g in edible portions of fish sampled in 1993.
- Uranium concentrations in background agricultural samples ranged from <0.004 pCi/g to 0.006 pCi/g.

9 ENVIRONMENTAL QUALITY ASSURANCE PROGRAM INFORMATION

9.1 Program Overview

The environmental quality assurance program includes management of the quality assurance/quality control programs, plans, and procedures governing environmental monitoring activities at the Weldon Spring Site Remedial Action Project (WSSRAP) and at the subcontracted off-site laboratories. This section discusses the environmental monitoring standards at the WSSRAP and the goals for these programs, plans, and procedures.

The environmental quality assurance program provides the WSSRAP with reliable, accurate, and precise monitoring data. The program furnishes guidance and directives to detect and prevent quality problems from the time a sample is collected until the associated data are evaluated and utilized. Key elements in achieving the goals of this program are compliance with the quality assurance program and environmental quality assurance program procedures, personnel training, compliance audits, use of quality control samples, complete documentation of field activities and laboratory analyses; and review of data documentation for precision, accuracy, and completeness.

9.1.1 Quality Assurance Program

The *Project Management Contractor Quality Assurance Program* (QAP) (Ref. 40) establishes the quality assurance program for activities performed by the Project Management Contractor (PMC). The QAP requires compliance with the criteria of DOE Order 5700.6C.

9.1.2 Environmental Quality Assurance Project Plan

Environmental compliance issues applicable to the WSSRAP are addressed in the WSSRAP *Environmental Quality Assurance Project Plan* (EQAPjP) (Ref. 41) which outlines the specific U.S. Environmental Protection Agency/Quality Assurance Management Staff (EPA/QAMS) Quality Assurance requirements for characterization and routine monitoring at the WSSRAP. The EQAPjP does not supersede the QAP, but rather expands on the specific requirements of environmental monitoring and characterization activities.

The primary purpose of this document is to provide a complete and accurate framework of information for assessing the amount and extent of hazardous materials present at the site. The EQAPjP is also supported by standard operating procedures (SOPs), the *Environmental Safety and Health Plan* (Ref. 42), the *Environmental Monitoring Plan* (EMP) (Ref. 9), and sampling plans written for specific environmental tasks.

9.1.3 Environmental Data Administration Plan

The *Environmental Data Administration Plan* (EDAP) (Ref. 43) summarizes SOPs and data quality requirements for collecting and analyzing environmental data. The EDAP describes administrative procedures for managing environmental data and governs sampling plan preparation, data verification and validation, database administration, and data archiving. Guidance on developing data quality objectives for specific investigations is also detailed. The EDAP details the specific requirements of the EQAPjP.

9.1.4 Environmental Monitoring and Quality Assurance Standard Operating Procedures

SOPs have been developed for routine activities at the WSSRAP. Environmental monitoring SOPs are generally administered by the Environmental Safety and Health (ES&H) Department, and Quality Assurance SOPs are administered by the Project Quality Department. These two departments are responsible for most SOPs used to administer the environmental quality assurance program described in this section. Controlled copies of SOPs are maintained in accordance with the document control requirements of the American Society of Mechanical Engineers (ASME) NQA-1 (1989). All SOPs are reviewed at least annually and revised as appropriate.

9.1.5 Use and Presentation of Data

Analytical data are received from subcontracted analytical laboratories. Uncensored data have been used in all reporting and calculations for this site environmental report where available. Uncensored data is that data which does not represent a ND (non-detect) and instead reports an actual value. This type of data is designated by parentheses around the data value, for example "(1.17)". If uncensored data were not available, nondetect data were used in calculations of averages at a value of one-half the detection limit (DL/2). The EPA recommends the use of the DL/2 value for statistical manipulation of data when the percentage of nondetects in the data set is small and uncensored data are not available (Ref. 44). In addition, all averages and summary calculations include the ratio of nondetect data to the total number of samples (e.g., 1:4) as required under the corrective action plan.

9.1.6 Audits

The environmental programs are audited by the Project Quality Department. Audits include self assessments, surveillances, and formal audits. They evaluate compliance with environmental programs and generate audit reports to track deficiencies and corrective actions. The WSSRAP is also audited routinely by external organizations including DOE Headquarters and the DOE Oak Ridge Operations Office. The external audits assess compliance with applicable regulations, DOE Orders, and site plans and procedures. All audit reports, deficiencies, and corrective actions are tracked using the Site Wide Audit Tracking System (SWATS).

9.1.7 Subcontracted Off-Site Laboratories Programs

Subcontracted off-site laboratories that performed analyses used in the preparation of this report use Contract Laboratory Program (CLP) methodologies when applicable. For certain analyses (such as radiochemical and wet chemistry) the laboratories are using EPA 600 (drinking water), EPA 900 (radiochemical analysis of drinking water), or methods that are reviewed and approved by the Project Management Contractor (PMC) prior to analysis of each sample. Each of the subcontracted off-site laboratories has submitted a site-specific *Quality Assurance Project Plan* (QAPjP) to the WSSRAP and controlled copies of their standard operating procedures. The QAPjPs and SOPs are reviewed and approved by the PMC before any samples are shipped to the laboratory. Changes to the standard analytical protocols or methodology are documented in the controlled SOPs. All of the laboratories currently being used by the WSSRAP have had a preliminary assessment of their facilities to make sure that they have the capability to perform work according to the specifications of their contracts. Quality assurance audits are performed annually to inspect the laboratory facilities and operations, to ensure that the laboratories are performing analyses as specified in their contracts, and to check that WSSRAP data documentation and records are being properly maintained.

9.2 Applicable Standards

Applicable standards for environmental quality assurance include: (1) use of the appropriate analytical and field measurement methodologies; (2) collection and evaluation of quality control samples; (3) accuracy, precision, and completeness evaluations; and (4) preservation and security of all applicable documents and records pertinent to the environmental monitoring programs.

9.2.1 Analytical and Field Measurement Methodologies

Analytical and field measurement methodologies used at the WSSRAP comply with applicable standards required by the DOE, EPA, and the American Public Health Association. Analytical methodologies used by subcontracted laboratories for environmental monitoring follow the EPA CLP requirements (metal and organic methodologies) and the EPA drinking water and radiochemical methodologies. Field measurement methodologies typically follow the *American Public Health Association Standard Methodologies for the Examination of Water and Wastewater* (Ref. 45).

9.2.2 Quality Control Samples

Quality control samples for environmental monitoring are collected in accordance with WSSRAP SOPs that specify the frequencies of quality control sample collection. Quality control samples are taken in accordance with the EPA CLP (Ref. 25).

Descriptions of the QC samples collected at the WSSRAP are detailed in Table 9-1.

TABLE 9-1 QC Sample Description

Type of Blank	Description
Distilled Water Blank	Monitors the purity of distilled water used for field blanks and decontamination of sampling equipment.
Field Blank	Monitors potential contaminants, such as dust or volatile compounds, that may be introduced at the site of sample collection. Field blanks are collected in the field at the same time of sample collection activities.

TABLE 9-1 QC Sample Description (Continued)

Type of Blank	Description
Equipment Blank	Monitors the effectiveness of procedures used to clean sampling equipment prior to collecting a sample. Equipment blanks include both rinsate and filter blanks.
Trip Blank	Monitors volatile organic compounds that may be introduced during transportation or handling at the laboratory.
Field Replicate	Monitors field conditions that may affect the reproducibility of samples collected from a given location.
Blind Duplicate	A replicate with a modified sample identification. The duplicate is used to monitor field conditions that may affect the reproducibility of samples collected from a given location.
Matrix Spike*	Monitors the accuracy of laboratory measurements for a given matrix type. The results of this analysis and the routine sample are used to compute the percent recovery for each parameter.
Matrix Duplicate*	Monitors the precision of laboratory measurements for inorganic parameters in a given matrix type. The results of the matrix duplicate and the routine sample are used to compute the relative percent difference for each parameter.
Matrix Spike Duplicate*	Monitors the precision of laboratory measurements for organic compounds. The matrix spike duplicate is spiked in the same manner as the matrix spike sample. The results of the matrix spike and matrix spike duplicate are used to determine the relative percent difference for organic parameters.

* Split a laboratory from large volume samples.

9.2.3 Accuracy, Precision, and Completeness

The WSSRAP data validation group determines the analytical accuracy, precision, and completeness of 10% of the environmental data collected. Data validation is required under DOE Order 5400.1.

9.2.4 Preservation and Security of Documents and Records

Requirements for preservation and security of documents and records are specified in DOE Order 5700.6C and ASME NQA-1 (1989). All documents pertinent to environmental monitoring are preserved and secured by the departments that produce them.

9.3 Quality Assurance Sample Results

The quality assurance program is assessed by analyzing quality control sample results and comparing them to actual samples using the following methodology.

9.3.1 Duplicate Analyses Results

Two kinds of duplicate analyses were performed in 1993; matrix spike duplicates and blind duplicates. The matrix spike duplicate analyses were performed at subcontracted laboratories from aliquots of original samples collected at the Weldon Spring site. Replicate or blind duplicate analyses were performed using samples split by the WSSRAP into separate containers and identified by separate identification numbers. Laboratory duplicates were used to assess the precision of analyses and also to aid in evaluating the homogeneity of samples or analytical interferences of sample matrixes.

Generally, laboratory duplicate samples were analyzed for the same parameters as the original samples at the rate of approximately one for every 20 samples. Blind duplicate (replicate) samples were collected as specified in the EMP (Ref. 9). Typically, duplicate samples were analyzed for the more common parameters: uranium, nitroaromatic compounds, inorganic anions, and metals.

When laboratory and blind duplicate samples were available, the average relative percent difference was calculated. This difference represents an estimate of precision. The equation used (as specified in the *USEPA Contract Laboratory Program, Inorganic Scope of Work*, [Ref. 25]) was:

$$RPD = (S-D)/((S+D)/2) \times 100$$

where S = the normal sample
D = the duplicate analysis

The relative percent difference was calculated only for samples whose analytical results exceeded five times the detection limit.

Table 9-2 summarizes the data on relative percent differences for groundwater (including springs) and surface water (including National Pollutant Discharge Elimination System [NPDES]) samples for the parameters of sufficient data size to permit averaging. Both the laboratory duplicates and the blind duplicates are summarized. When the relative percent difference data could not be averaged, they were not evaluated because these parameters were not commonly analyzed for and/or were not contaminants of concern.

TABLE 9-2 Summary of Calculated Relative Percent Differences

	Groundwater [a]		Surface Water [b]	
	Duplicates		Duplicates	
Parameter	RPD [c]	Count No.	RPD [c]	Count No.
Alkalinity	1.99	39	1.38	11
Nitrate-N	3.60	20	1.23	6
Sulfate	2.67	24	1.06	2
Chloride	3.91	26	5.23	3
Arsenic	3.45	20	1.09	17
Barium	3.19	27	1.56	4
Calcium	12.56	28	1.08	4
Magnesium	4.30	20	1.21	4
Manganese	2.29	18	1.21	4
Potassium	10.24	16	11.43	5
Sodium	4.30	18	1.01	6
Strontium	8.77	24	1.96	2
Silica, dissolved	1.45	21	(d)	0
Uranium, total	2.09	26	1.24	15

(a) Groundwater samples include spring samples
(b) Surface water samples include NPDES samples
(c) RPD = Relative Percent difference
(d) RPD could not be calculated for these parameters

The results in Table 9-2 indicate for all parameters reviewed, that the 20% criterion as recommended in the CLP (Ref. 25 and 44) demonstrates that duplicate sample results were reproduced and were of acceptable quality.

9.3.2 Blank Sample Results Evaluation

Various types of blanks are collected by the WSSRAP to assess the conditions and/or contaminants that may be present during sample collection and transportation. These conditions and contaminants are monitored by collecting samples to ensure routine samples are not being contaminated. Blank samples assess the:

- Environments that the samples (i.e., volatile analyses) were shipped in (trip blanks).
- Ambient conditions in the field that may effect a sample during collection (field/trip blanks).
- Effectiveness of the decontamination procedure for sampling equipment used to collect samples (equipment blanks).
- Quality of water used to decontaminate sampling equipment and/or assess the ambient conditions (distilled water blanks).

Sections 9.3.2.1 through 9.3.2.4 discuss the sample blank analyses and the summary of analytical results that were above the analytical detection limits. Field blank samples for groundwater, surface water, spring and seep water, and NPDES water were evaluated together as a set.

9.3.2.1 Trip Blank Evaluation. Trip blanks are collected to assess the impact of sample collection and shipment on groundwater and surface water samples analyzed for volatile organic compounds. Trip blanks are sent to the laboratory with each shipment of volatile organic samples.

In 1993, eight trip blank samples were analyzed for volatile organic compounds. Low concentrations of acetone were found in two samples. The acetone concentrations were just above the detection limit and the concentrations did not exceed the CLP criterion. This compound is a common laboratory contaminant.

TABLE 9-3 Summary and Average of Field Blank Parameter Results

Parameters	Number of Detects/Number of Analyses	Evaluation and Summary of Detects	Comments
Uranium, total	6 out of 16 (23%)	4 of 6 (33%) <5 x DL 2 of 6 (33%) >5 x DL	-
Nitrate-N	3 out of 12 (25%)	2 of 3 (67%) <5 x DL 1 of 3 (33%) >5 x DL	Lab problem/contamination
Chloride	0 out of 6 (0%)	N/A	-
Sulfate	2 out of 7 (30%)	2 of 2 (100%) <2 x DL	-
Alkalinity	4 out of 18 (22%)	3 of 4 (75%) <2 x DL 1 of 4 (25%) >2 x DL	-
Lead	3 out of 6 (50%)	1 of 3 (33%) >2 x DL 2 of 3 (67%) <2 x DL	one rejected by validation group
Iron	3 out of 16 (19%)	3 of 3 (100%) <2 x DL	-
Sodium/Strontium	0 out of 5 (0%)	NA	-
Calcium	4 out of 7 (57%)	4 of 4 (100%) <5 x DL	-
Phosphorus	2 out of 5 (40%)	2 of 2 (100%) <2 x DL	-
Thorium-230	1 out of 4 (25%)	1 of 1 (100%) <2 x DL	-
Toluene	0 out of 3 (0%)	N/A	-
Arsenic/Barium	0 out of 14 (0%)	N/A	-
Nitroaromatic	0 out of 12 (0%)	N/A	-

DL Detection limit; <2X = Less than two times; >5X = greater than five times
N/A Not Applicable

9.3.2.2 Field Blank Evaluation. Field blank samples are collected at monitoring sites just prior to, or immediately after, actual samples are collected. The field blanks are collected to assess the ambient air conditions at the sample locations. They are analyzed for the parameters being sampled which, therefore, are generally the parameters of concern, such as uranium, anions, metals, and nitroaromatics.

The data is summarized in Table 9-3. This table presents the ratio of detects to total number of samples collected for each parameter having results above the detection limits.

9.3.2.3 Equipment and Bailer Blank Evaluation. Equipment and bailer blanks are collected by rinsing decontaminated equipment and bailers with distilled water, and collecting the rinse water. This procedure is used to determine the effectiveness of the decontamination process. At the WSSRAP, most of the groundwater samples are collected from dedicated equipment, and surface water is collected by placing the sample directly into a sample container. The data for the equipment blanks did not detect contamination; therefore no further discussion is presented.

9.3.2.4 Distilled Water Blank Evaluation. Water blank samples are collected to evaluate the quality of the distilled water used to decontaminate sampling equipment and to assess whether contaminants are present in the water used for field and trip blanks. Water blank samples also serve as laboratory blanks. ES&H 4.1.4 states that water blank samples shall be collected on a monthly basis. Generally, the water blanks were analyzed for contaminants of concern and were collected at the same time as field blanks.

In 1993, 22 water blanks were collected. Table 9-4 presents the ratio of detects to the total number of samples collected for each parameter that had results above the detection limit. All of the contaminants found in water blank samples were low level (less than five times the detection limit); therefore there is no impact on the routine samples.

TABLE 9-4 Summary of Water Blank Parameter Results

Parameter	Number of Detects/Number of Analyses	Evaluation and Summary of Detects
Uranium, total	5 out of 19 (26%)	2 of 5 at DL 3 of 5 <5 x DL
Nitrate-N	2 out of 12 (17%)	2 of 2 at DL
Chloride	3 out of 7 (43%)	3 of 3 <2 x DL
Alkalinity	2 out of 9 (22%)	2 of 2 <2 x DL
Chemical Oxygen Demand	No Detections	N/A
Iron	3 out of 8 (38%)	2 of 3 <2 x DL 1 of 3 <5 x DL
Lead	2 out of 9 (22%)	2 of 2 <2 x DL
Magnesium	1 out of 5 (20%)	1 of 1 <2 x DL
Mercury	No Detection	N/A
Phosphorus	1 out of 5 (20%)	1 of 1 <2 x DL
Sodium	No Detection	N/A

TABLE 9-4 Summary of Water Blank Parameter Results (Continued)

Parameter	Number of Detects/Number of Analyses	Evaluation and Summary of Detects
Strontium	1 out of 3 (33%)	1 of 1 <2 x DL
Thorium-230	No Detection	N/A
All other[a]	No Detection	N/A

(a) Nitroaromatic, other metals and radiochemical parameters
N/A Not Applicable

9.4 1993 Data Validation Program Summary

Data validation programs at the WSSRAP involve reviewing and qualifying at least 10% of the data collected during a calendar year. The information summarized below includes all WSSRAP data collected and is not limited to environmental monitoring data. The data points represent the number of parameters analyzed (e.g., toluene), not the number of physical analyses performed (e.g., volatile organics analyses).

Table 9-5 identifies the number of 1993 quarterly and total data points that were selected for data validation, and what percentage of those selected were completed.

Table 9-6 identifies validation qualifiers assigned to the selected data points as a result of data validation. To date, 54.6% of 1993 data validation has been completed.

Table 9-7 identifies the average accuracy and precision for all sample types excluding environmental and waste management samples for anion, metal, nitroaromatic, radiochemical, and miscellaneous parameters. The accuracy values are based on the percent recoveries of the laboratory control samples, and the precision values are based on the relative percent difference between duplicates. The data population size associated with each accuracy and precision value is listed as "n."

TABLE 9-5 WSSRAP Validation Summary for Calendar Year 1993 (as of January 1994)

Calendar Quarter 1993	No. of Data Points Collected	No. of Data Points Selected for Validation	No. of Validated Data Points	% Completed
Quarter 1	14,392	1,621	1,425	87.9
Quarter 2	16,393	1,890	1,831	97.4
Quarter 3	16,258	1,735	1,315	77.1
Quarter 4	30,932	3,140	2	0.1
1993 Total	77,975	8,346	4,573	54.8

061994

TABLE 9-6 Annual Data Validation Qualifier Summary - 1993 (as of January 1994)

	No. of Data Points								
	Anions	Metals	Miscellaneous	Nitroaromatics	Pest/PCB	Radiochemical	Semi-VOA	VOA	Total
Accepted	329	830	364	191	289	423	1,090	912	4,428
Rejected	10	73	4	19	0	22	8	9	145
On Hold	3	0	0	18	53	58	164	54	350
Not Validatable	1	0	1	0	0	0	0	0	2
Pending	0	564	1	1,078	550	586	672	0	3,451
Total	343	1,467	370	1,306	892	1,089	1,934	975	8,376
	Percentages								
Accepted	95.9	56.6	98.4	14.6	32.4	38.9	56.4	93.5	52.9
Rejected	2.9	5.0		1.5	0	2.0	0.4	1.0	1.7
On Hold	0.9	0	0	1.4	5.9	5.3	8.5	5.5	4.2
Not Validatable	0.3	0	0.3	0	0	0	0	0	0.02
Pending	0	38.4	0.3	82.5	61.7	53.8	34.7	0	41.2
Total	100	100	100	100	100	100	100	100	100

TABLE 9-7 Validation Accuracy and Precision Summary for Calendar Year 1993

Parameter	Acc.[a]	n[b]	Prec.[c]	n[b]
ANIONS				
Fluoride	99.6	16	0.0	6
Chloride	98.7	30	3.2	28
Nitrate-N	103.4	250	3.0	246
Sulfate	96.0	68	3.9	67
METALS				
Aluminum	102.2	12	1.6	12
Antimony	102.2	11	1.0	11
Arsenic	99.9	62	3.4	56
Barium	99.1	97	7.2	86
Beryllium	102.8	12	1.0	12
Cadmium	102.3	48	8.9	28
Calcium	106.1	16	10.2	16
Chromium	102.3	54	4.3	37
Cobalt	104.5	5	1.5	5
Copper	102.2	23	1.7	8
Iron	104.5	30	4.3	21
Lead	100.3	56	7.7	40
Lithium	102.5	20	12.5	15
Magnesium	99.6	12	1.3	12
Manganese	102.6	30	1.9	21
Mercury	104.0	46	1.1	25
Molybdenum	102.9	5	0.7	5
Nickel	103.1	12	1.1	12
Potassium	99.0	12	4.6	12
Selenium	97.1	47	13.7	28
Silver	98.1	54	4.4	29
Sodium	108.0	12	2.0	12
Thallium	103.0	8	7.8	8

TABLE 9-7 Validation Accuracy and Precision Summary for Calendar Year 1993 (Continued)

Parameter	Acc.[a]	n[b]	Prec.[c]	n[b]
METALS (continued)				
Vanadium	102.6	5	0.4	5
Zinc	94.5	41	10.4	32
MISCELLANEOUS				
Alkalinity	98.8	214	2.4	213
Total Dissolved Solids	--	0	--	0
Total Suspended Solids	95.2	33	9.2	14
Cyanide, Total	94.6	16	4.8	1
Biochemical Oxygen Demand	91.8	16	0.0	1
Chemical Oxygen Demand	76.9	16	0.0	7
NITROAROMATICS				
1,3,5-Trinitrobenzene	96.5	5	2.4	4
1,3-Dinitrobenzene	96.6	5	1.4	4
Nitrobenzene	93.4	5	0.4	4
2,4,6-Trinitrotoluene	96.7	16	0.9	15
2,4-Dinitrotoluene	98.8	16	3.5	15
2,6-Dinitrotoluene	96.4	5	0.8	4
RADIOCHEMICAL				
Uranium, Total	96.2	56	2.3	53
Th-228	95.7	24	4.0	15
Th-230	99.1	24	7.0	15
Th-232	93.1	24	4.8	15
Ra-226	101.3	15	6.3	15
Ra-228	98.7	15	9.2	15
Gross Alpha	99.9	17	14.0	13
Gross Beta	93.1	13	7.5	13

a The accuracy values are based on the percent of recoveries of the associated laboratory control samples.
b Sample Population
c The precision values are based on the relative percent of differences between associated sample duplicates or duplicate laboratory control standards

9.5 Interlaboratory Comparison Program Results

This section summarizes the interlaboratory comparison program data received from the subcontracted laboratories. Data presented in this section are from three programs: (1) the DOE quality assessment program, (2) EPA organic and inorganic performance evaluation studies and (3) the EPA intercomparison radionuclide control program.

The interlaboratory comparison programs are intended to allow participating laboratories to analyze spiked control standards to verify how their SOPs and quality assurance/quality control (QA/QC) programs are performing. Interlaboratory comparison program results presented in this section do not impact any of the analytical data used to prepare this report, but are discussed here to provide information about laboratories' capability to perform accurate analyses of spiked control samples.

Results of the DOE Environmental Measurement Laboratory Quality Assessment Program are presented in Table 9-8. This table provides information on the parameter, matrix type, laboratory name, date analyzed, DOE value, reported value, and percent recovery.

Results of the EPA intercomparison radionuclide control program are presented in Table 9-9. This table provides information on the parameter, matrix type, laboratory name, date analyzed, DOE value, reported value, and the percent recovery.

Results of the EPA organic and inorganic performance evaluation program are not presented in this section. However, this information is evaluated during the routine audit of each laboratory. Results of the 1993 performance evaluation samples have been renewed, and no major problems with the results from these programs were observed.

TABLE 9-8 Summary of DOE Interlaboratory Comparison Program

Parameter (matrix)	Laboratory (Date)		DOE Value	Reported Value	Percent Recovery
Uranium, total pCi (water)	IT	4/93	0.729	0.308	42%
Uranium, total μg (water)	IT	3/93	0.842	0.100	12%
Uranium, total pCi (soil)	IT	9/93	28.9	31.30	92%
Uranium, total μg (soil)	IT	9/93	0.255	0.127	50%
Uranium, total pCi (air)	IT	9/93	0.541	0.523	97%
Uranium, total μg (water)	Barringer	2/93	0.108	0.100	93%
Uranium, total μg (air)	Barringer	9/93	0.650	0.680	105%
Uranium, total μg (soil)	Barringer	1/93	2.32	2.10	91%
Uranium, 234 pCi (water)	Barringer	1/93	0.115	0.137	119%
Uranium, 238 pCi (water)	Barringer	4/93	0.115	0.115	100%
Uranium, 234 pCi (air)	Barringer	4/93	0.0166	0.0204	123%
Uranium, 238 pCi (air)	Barringer	1/93	0.160	0.0204	127%
Uranium, 234 pCi (soil)	Barringer	1/93	29.2	18.5	63%
Uranium, 238 pCi (soil)	Barringer	1/93	29.6	14.8	50%
Uranium, total pCi (water)	Ecotek	2/93	0.842	0.734	84%
Uranium, 234 pCi (water)	Ecotek	3/93	0.106	0.108	102%
Uranium, total pCi (air)	Ecotek	9/93	0.541	0.705	130%
Uranium, 234 pCi (air)	Ecotek	2/93	0.02	0.023	115%
Uranium, 234 pCi (soil)	Ecotek	4/93	25.6	31.3	122%

TABLE 9-9 Summary of EPA - EMSL Intercomparison Radionuclide Control Program

Parameter (Matrix)	Laboratory (Date)		EPA EMSL Value	Average Reported Value	Percent Recovery
Uranium, total (water)	Barringer	4/93	24.8	20.31	82%
Uranium, total (water)	Barringer	9/93	8.9	7.62	86%
Gross Alpha (water)	Barringer	1/93	15.0	12.93	86%
Gross Alpha (water)	Barringer	9/93	32.0	27.57	86%
Gross Beta (water)	Barringer	9/93	39.0	38.76	99%
Gross Beta (water)	Barringer	9/93	46.0	41.24	90%
Radium-226 (water)	Barringer	1/93	11.2	11.01	98%
Radium-226 (water)	Barringer	4/93	24.9	23.9	96%
Radium-228 (water)	Barringer	3/93	18.9	21.33	113%
Radium-228 (water)	Barringer	4/93	19.0	23.33	123%
Uranium, total (water)	Ecotek	1/93	9.0	8.57	95%
Uranium, total (air)	Ecotek	4/93	20.6	22.56	110%
Uranium, total (water)	Ecotek	4/93	6.0	5.69	95%
Uranium, total (water)	Ecotek	9/93	6.0	6.71	112%
Uranium, total (water)	Ecotek	10/93	8.0	8.65	108%
Gross Alpha (water)	Ecotek	4/93	21.0	19.78	94%
Gross Alpha (water)	Ecotek	9/93	38.0	43.22	114%
Gross Beta (water)	Ecotek	1/93	19.0	15.43	81%
Gross Beta (water)	Ecotek	9/93	40.0	43.12	108%
Radium-226 (water)	Ecotek	4/93	18.0	15.76	88%
Radium-226 (water)	Ecotek	9/93	18.0	16.39	91%
Radium-228 (water)	Ecotek	1/93	8.0	10.21	128%
Radium-228 (water)	Ecotek	9/93	10.0	6.53	65%

10 SPECIAL STUDIES

This section highlights significant activities and efforts at the Weldon Spring Site Remedial Action Project that support and assist in the implementation of environmental protection policies. In addition, short term environmental studies are described that support regulatory requirements not specifically covered by U.S. Department of Energy (DOE) Order 5400.1 or that were not planned in the *Environmental Monitoring Plan for Calendar Year 1993* (Ref. 9).

10.1 Special Programs

The special programs described in this section were initiated to determine the effectiveness of engineering practices put in place as a result of remedial activities at the site. In addition, research activities were developed to support overall environmental monitoring.

10.1.1 Dam Safety Operations Program

Federal regulations require that embankments higher than 7.6 m (25 ft) and those that could pose a significant downstream hazard be regulated by a dam safety operations program. The Federal Energy Regulatory Commission has the overall responsibility for embankments owned by the Department of Energy and performs formal inspections annually. The Weldon Spring Site Remedial Action Project (WSSRAP) is responsible for the development and implementation of the dam safety operations program, maintenance of the embankments, and the performance of routine surveillance of the structures.

The WSSRAP has implemented the dam safety operations program which was developed in 1991 and formalized in 1992. This program outlines the training necessary to effectively survey and assess the embankments at both the chemical plant and quarry and requires mandatory surveys as outlined in procedure ES&H 4.2.3s. All regulatory and surveillance requirements, including documentation are also defined by this program. The *Dam Safety Operations Emergency Preparedness Plan* (Ref. 46) outlines actions to be taken in the event of possible or actual embankment failures.

In 1993, all embankments at the site were assessed in accordance with the requirements of these documents. Only minor deficiencies were noted. General maintenance consisting of mowing weeds and grass, removing woody vegetation, and filling abandoned animal burrows was performed throughout the year. An elevation survey was performed to identify possible slump areas on the crests of Raffinate Pit 3 embankments. Identification of the lower areas was necessary due to the higher water elevations sustained throughout the year.

A formal five year inspection was performed by an independent consultant in accordance with the regulations of the Federal Energy Regulatory Commission. During the formal inspection, consideration was given to the higher water levels in Raffinate Pit 3 and its pre-existing over-steepened slope. A slope stability investigation consisting of soil borings, phreatic surface determination, geotechnical soil testing, and additional inspections was performed to determine the soundness of the structure. The results of the investigation indicated that the water level of the raffinate pit does not have a significant bearing on the stability of the slope because no substantial phreatic surface exists through the earthen embankments.

10.1.2 Storm Water Runoff Monitoring Program

Due to the increased remedial and construction activity in contaminated soil areas at the chemical plant, erosion and sediment control measures have been implemented to reduce the sediment load in storm water runoff from the site. These measures are regulated by the National Pollutant Discharge Elimination System (NPDES). As an internal measure only, storm water runoff samples were collected and analyzed for settleable solids and total uranium to determine the effectiveness of current erosion and sediment control around storage and construction areas at the site.

Sampling was scheduled to be performed monthly during or after measurable storm events; therefore, if no storm events occurred during the month, no samples were collected. The effectiveness of the controls was determined by sampling runoff on the down slope side of sediment barriers and comparing parameter concentration levels to historical data for each sampling location. Activities taking place within the construction or storage area were also taken into account when evaluating changes in concentrations. Changes were made to control systems if the concentrations were significantly higher than historical data. Some locations were also deleted after activities ceased and concentrations from the area reached background levels. To assess the effectiveness of erosion and sediment control work practices, this program will continue while soil disturbance activities are in process.

10.1.3 Environmental Internship

In 1991, the WSSRAP initiated an environmental internship program to encourage and cultivate young environmental professionals who, in many cases, will dedicate extended careers to environmental protection, waste management, and remedial activities. Another goal of this program was to provide students from local public and private colleges internship opportunities. The internship program provides 24 hour or 40 hour hazardous materials training, radiation safety, and other appropriate instruction to the interns.

In 1993, the program supported two environmental internships for industrial hygienists. The industrial hygiene internships included field activities including contamination surveys, calibration of instruments, noise monitoring, hazardous atmosphere determination, and heat stress monitoring.

10.2 Special Studies

The special studies described in this subsection are short-term or one-time studies that support regulatory requirements not specifically covered by DOE 5400.1 or which were not planned in the *Environmental Monitoring Plan for Calendar Year 1993* (Ref. 9). These studies are applicable to the monitoring requirements of DOE Order 5400.1 for preoperational monitoring and baseline characterization.

10.2.1 Particle Sizing Study

Particle sizing studies were initiated in 1991. A knowledge of particle size within different areas or buildings on the site is vital to assessing the potential health effects associated with exposures to airborne particulates. Particle size distributions are essential in determining the probable point of respiratory deposition, particle behavior in the air, and in conducting an overall evaluation of chemical and radiological hazards. The particle sizing study should reproduce, to a reasonable degree, the dust collecting characteristics of the human respiratory system so that lung penetration by airborne particles can be predicted from sampling data.

The more penetrable or smaller particles possess a greater potential to deliver radiation dose and other hazardous effects. The International Commission on Radiation Protection (ICRP) dosimetric models apply a default value of one micrometer to the determination of dose conversion factors. However, actual sample collection in most of the heavily contaminated buildings on site has indicated that the median particle size is much greater than this default value. Table 10-1 lists the buildings that have been sampled and the median particle sizes measured on each occasion.

TABLE 10-1 Median Particle Sizes Measured for Buildings Sampled

Building	Collection Date	AMAD* (μm)
301	01-15-93	7.0
301	07-28-92	6.6
201	01-22-93	4.1
201	09-15-93	5.6
101	10-06-93	6.0
108	11-09-93	5.8
408	11-10-93	6.3
433	11-16-93	1.1

*AMAD - Activity Median Aerodynamic Diameter

The average value measured for all locations was 5.1 micrometers, which is much larger than the accepted value of 1 micrometer used in many radiation dose prediction models. A particle size of this magnitude would result in approximately three times less committed effective dose equivalents for any given inhalation intake in the workplace. Data collection will continue on a biannual basis at all locations where work activities create a potential for workers to receive a committed effective dose equivalent in excess of 100 mrem.

10.2.2 Flood Impacts in the Weldon Spring Quarry Area

During 1993, the Missouri River valley in the vicinity of the Weldon Spring site experienced extensive flooding. The unusually heavy rain of the spring and summer caused the inundation of the St. Charles County well field on July 15 and September 26, 1993. The Femme Osage Slough overflowed its banks several times between January and September of 1993. The highest water level at the quarry water treatment plant occurred on July 31, 1993 at 477.3 ft MSL, 3 ft above the 500 year flood levels. The quarry water treatment plant basins were not inundated.

The well field, separated from the quarry by the Femme Osage Slough, contains the county production wells, which provide drinking water for portions of St. Charles County. While the quarry is contaminated, both chemically and radiochemically, these contaminants have not compromised the integrity of the drinking water supply.

10.2.2.1 Groundwater Impacts. Before the St. Charles County well field was completely inundated, the Femme Osage Slough had been out of it banks several times since January 1993 due to heavy rains. The high water level in the slough caused many monitoring wells, specifically MW-1006 through MW-1009, and MW-1032, to be inaccessible for about 6 months. Evidence that the rising water of the Missouri River was effecting groundwater conditions was noted when several monitoring wells became artisan and sand boils were observed near the levee.

Prior to inundation of the well field, monitoring wells adjacent to the north side of the Femme Osage Slough were showing higher than normal concentrations of total uranium and/or nitroaromatic compounds. Monitoring wells MW-1030 (bedrock rim) and MW-1032 (bedrock) exhibited elevated concentrations of several nitroaromatic compounds and total uranium prior to and during the period that the St. Charles County well field was flooded. These compounds had been detected at these locations previously but not at the levels exhibited during these sampling events. Elevated total uranium concentrations were also exhibited in groundwater from bedrock rim monitoring well MW-1030 from the July and August sampling events. These two samples were obtained during periods of greatest flooding in the well field. The static water level in the bedrock was higher than normal during this time, possibly causing the movements of the contaminants to be impeded in this location, which resulted in higher than normal concentrations of total uranium.

Due to the flood, 26 monitoring locations (22 DOE and four St. Charles County) were submerged and most were not sampled during the third quarter of 1993. These wells are located adjacent to the Femme Osage Slough. Four of the eight St. Charles County production wells were placed out of service due to flooding of the pumps. The four operating production wells were sampled by boat at the end of September 1993, during the second inundation of the well field. All production well results for total uranium were less than the detection limit (<1.00 pCi/l).

Between well field inundations, the water receded enough to gain access to the groundwater monitoring wells adjacent to the south side of the Femme Osage Slough (MW-1017 through MW-1022). Grab samples were obtained from these monitoring wells and analyzed for total uranium. The results are consistent with historical data from these locations and are summarized in Table 10-2.

TABLE 10-2 Summary of Total Uranium Result South of Slough

Monitoring Well	Total Uranium (pCi/l)
MW-1018	0.78
MW-1019	2.98
MW-1020	1.82
MW-1021	0.93
MW-1022	1.46

10.2.2.2 Surface Water Impacts. During the first bimonthly period, one surface water location in the Femme Osage Slough, SW-1004, showed a total uranium concentration (4012 pCi/l) which exceeded the historic high of 557 pCi/l. A re-analysis of the sample confirmed previous results. The second bimonthly sample showed the total uranium concentration to be 100 pCi/l.

Review of the initial sampling event indicated that the Femme Osage Slough had been flooded and was out of its banks. Surface water sampling location SW-1004 is situated near Vicinity Property 9, an area of known soil and groundwater contamination. The surface water sample was obtained from a shallow area of water located over Vicinity Property 9 that is typically not submerged. During the second bimonthly period, the water in the slough returned to a normal level, and a sample was obtained from its typical location.

During April 1993, the Femme Osage Slough again flooded and overflowed its banks. At this time, an investigation consisting of surface water sampling, static water level measurement, and surface water level measurement was initiated to determine if the concentrations from the first bimonthly period could be recreated. Results of the investigation indicated that at the time of the initial sampling, the rising surface water likely caused an intermingling of contaminated groundwater with the surface water, which resulted in an elevated total uranium concentration at the location. Subsequent sampling of the slough during these similar conditions indicated that the area of impact was small, with respect to the entire slough, and the event was of short duration. Although no concentrations greater than 4000 pCi/l could be recreated, concentrations in excess of 1000 pCi/l were observed.

During October 1993, five surface water samples were collected at various locations along the Katy Trail from the flooded Femme Osage Slough to determine any changes in total uranium concentration. Results showed that the total uranium concentrations were below those levels normally exhibited in the slough and are summarized in Table 10-3.

Table 10-3 Femme Osage Slough Surface Water Samples (10/13/93)

Sample ID	Location Description	Total Uranium (pCi/l)
SW-KT01	Western end of the Little Femme Osage Slough	4.0
SW-KT02	Near MW-1013, MW-1014, and MW-1031	9.2
SW-KT03	Mid-point between SW-KT02 and SW-KT04	36.5
SW-KT04	Near MW-1008, MW-1009, and MW-1032	7.0
SW-KT05	Near MW-1015 and MW-1016	3.4

Conclusions

The results of the groundwater monitoring during and after the flood indicate that although levels of total uranium and nitroaromatic compounds have increased in several monitoring locations north of the slough, no adverse impact has occurred to date in the groundwater south of the slough or in the waters produced in the St. Charles County well field.

The results of the surface water investigations indicate that typical groundwater migration from the quarry is occurring and the flooded conditions have not caused an increase in the concentrations of contaminants entering the waters of the Femme Osage Slough.

11 REFERENCES

1. MK-Ferguson Company and Jacobs Engineering Group, 1989. *Remedial Investigation for Quarry Bulk Wastes*, Rev. 1. DOE/OR/21548-066. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. December.

2. MK-Ferguson Company and Jacobs Engineering Group, 1992. *Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site*, Volume 1. DOE/OR/21548-074. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. November.

3. Kleeschulte, M.J., L.F. Emmett, and J.H. Barks, 1986. *Hydrologic Data for the Weldon Spring Radioactive Waste-Disposal Sites, St. Charles County, Missouri-1984-1986*. Open-File Report 86-488. U.S. Geological Survey. Rolla, MO.

4. Berkeley Geosciences Associates, 1984. *Characterization and Assessment for the Weldon Spring Quarry Low-Level Radioactive Waste Storage Site*. DOE/OR-853 (DE85005424). Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. Berkeley, CA. September.

5. MK-Ferguson Company and Jacobs Engineering Group, 1992. *Agricultural Sampling Plan*, Rev. 1. DOE/OR/21548-229. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. December.

6. Argonne National Laboratory, 1990. *Feasibility Study for Management of the Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri*. DOE/OR/21548-104. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. Prepared by the Environmental Assessment and Information Sciences Division. St. Charles, Missouri. February.

7. Ruffner, J.A., 1978. *Climate of the States*. Gale Research Company. Detroit.

8. MK-Ferguson Company and Jacobs Engineering Group, 1993. *Environmental Protection Program Implementation Plan*, Rev. 5. DOE/OR/21548-095. Prepared for the U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. November.

9. MK-Ferguson Company and Jacobs Engineering Group, 1993. *Environmental Monitoring Plan for 1993*, Rev. 1. DOE/OR/21548-349. Prepared for the U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. June.

10. U.S. Department of Energy, 1993. *Record of Decision for Remedial Action at the Chemical Plant Area of the Weldon Spring Site*, Rev. 0. DOE/OR/21548-376. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. September.

11. Argonne National Laboratory, 1993. *Work Plan for the Remedial Investigation/ Feasibility Study-Environmental Assessment For the Quarry Residuals Operable Unit at the Weldon Spring Site*. DOE/OR/21548-243. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. November.

12. MK-Ferguson Company and Jacobs Engineering Group, 1994. *Quarry Residuals Sampling Plan*, Rev. 1. DOE/OR/21548-382. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. January.

13. MK-Ferguson Company and Jacobs Engineering Group, 1992. *Groundwater Protection Program Management Plan*, Rev. 3. DOE/OR/21548-123. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. July.

14. MK-Ferguson Company and Jacobs Engineering Group, 1992. *Surface Water Management Plan*, Rev. 0. DOE/OR/21548-221. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. June.

15. U.S. Department of Energy, 1994. *U.S. Department of Energy Radiological Control Manual*, Rev. 1. DOE/EH-0256T. Assistant Secretary for Environment, Safety and Health. Washington, D.C. April.

16. MK-Ferguson Company and Jacobs Engineering Group, 1994. *Waste Minimization/ Pollution Prevention Awareness Plan*, Rev. 2. DOE/OR/21548-124. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. March.

17. MK-Ferguson Company and Jacobs Engineering Group, 1993. *Self-Assessment Program Implementation Plan*, Rev. 0. DOE/OR/21548-385. Prepared for the U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. October.

18. Federal Emergency Management Agency, 1992. Flood Insurance Rate Map, Map Number 29183C0105 D, Panel 105 of 250, Federal Emergency Management Agency, 1992.

19. Argonne National Laboratory, 1993. *Mitigation Action Plan For the Remedial Action at the Chemical Plant Area of the Weldon Spring Site*. Rev. 0. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. November.

20. MK-Ferguson Company and Jacobs Engineering Group, 1994. *Waste Management Plan*, Rev. 5. DOE/OR/21548-166. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. March.

21. MK-Ferguson Company and Jacobs Engineering Group, 1994. *Plan for Monitoring Radionuclide Emissions Other Than Radon at Weldon Spring Site Critical Receptors*, Rev. 2. DOE/OR/21548-127. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. February.

22. International Commission on Radiological Protection, 1977. *Recommendations of the International Commission on Radiological Protection*. Radiation Protection Publication No. 26. Pergamon Press, New York. (Adopted January 17, 1977).

23. International Commission on Radiological Protection, 1978. *Limits for Intakes of Radionuclides by Workers*. Radiation Protection Publication 30, Part 1. Pergamon Press. Oxford.

24. Eckerman, K.F., A.B. Wolbarst, and A.C.B. Richardson, 1988. *Limiting Values of Radionuclide Intake and Air Concentration, and Dose Conversion Factors for Inhalation, Submersion, and Ingestion: Derived Guides for Control of Occupational Exposure and Exposure-to-Dose Conversion Factors for General Application*. Federal Guidance Report No. 11. Based on the 1987 Federal Radiation Protection Guidance. Prepared by the Oak Ridge National Laboratory for the U.S. Environmental Protection Agency, Office of Radiation Programs. Oak Ridge, TN.

25. U.S. Environmental Protection Agency, 1988. *USEPA Contract Laboratory Program Statement of Work for Inorganic Analysis: Multi-Media, Multi-Concentration*. SOW No. 788, 0900206R1.

26. Missouri Department of Conservation, 1991. *Recreational Use of Weldon Spring Wildlife Area 1989-1990*. Public Profile 6-91. June.

27. International Commission on Radiological Protection, 1981. *Limits for Inhalation of Radon Daughters by Workers*. Radiation Protection Publication No. 32. Pergamon Press, New York. (Adopted March 1981).

28. U.S. Environmental Protection Agency, 1988. *Superfund Exposure Assessment Manual*. OSWER Directive 9285.5-1.

29. Environmental Science & Engineering, Inc., 1993. *Aquatic Biological Monitoring*. ESE No. 592-1043-0400. Prepared for M-K Ferguson Company. St. Louis, MO. March.

30. Cember, Herman, 1983. *Introduction to Health Physics*, 2nd ed. Pergamon Press, New York.

31. United Nations Scientific Committee on the Effects of Atomic Radiation, 1982. 37th Session, Suppl. No. 45 (A/37/45). United Nations, New York.

32. U.S. Department of Energy, 1991. *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*. DOE/EH-0173T. Assistant Secretary for Environment, Safety and Health. Washington, DC. January.

33. MK-Ferguson Company and Jacobs Engineering Group, 1991. *WSSRAP Chemical Plant Surface Water and Erosion Control Report*, Rev. 0. DOE/OR/21548-253. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. October.

34. U.S. Environmental Protection Agency, 1986a. *Quality Criteria for Water 1986*. EPA 440/5-86-001. Office of Water Regulation and Standards. Washington DC. May 1.

35. Missouri Department of Natural Resources, 1992. *Rules of Department of Natural Resources Division 20 - Clean Water Commission*. Chapter 7, "Water Quality."

36. Schumacher, J.G., 1993. *Geochemistry and Migration of Contaminants at the Weldon Spring Chemical Plant Site, St. Charles County, Missouri--1989-91*. Open-File Report 93-433. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office by the U.S. Geological Survey. Rolla, MO.

37. Argonne National Laboratory, 1989. *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry*. DOE/OR/21548-039. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. Prepared by M.M. MacDonell, J.M. Peterson, and I.E. Joya of the Energy and Environmental Systems Division. January.

38. L.A. Haroun, J.M. Peterson, M.M. MacDonell, and I. Hlohowskyj, 1990. *Baseline Risk Evaluation for Exposure to Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri*. DOE/OR/21548-065. Prepared for the U.S. Department of Energy, Oak Ridge Operation Office by Argonne National Laboratory Environmental Assessment and Information Sciences Division. January.

39. U.S. Environmental Protection Agency, 1986. *RCRA Groundwater Monitoring Technical Enforcement Guidance Document*. OSWER-9950. September.

40. MK-Ferguson Company and Jacobs Engineering Group, 1992. *Project Management Contractor Quality Assurance Program*, Rev. 0. DOE/OR/21548-333. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. September.

41. MK-Ferguson Company and Jacobs Engineering Group, 1993. *Environmental Quality Assurance Project Plan*, Rev. 1. DOE/OR/21548-352. Prepared for the U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. July.

42. MK-Ferguson Company and Jacobs Engineering Group, 1992. *Environmental Health and Safety Plan*, Rev. 2. DOE/OR/21548-172. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. February.

43. MK-Ferguson Company and Jacobs Engineering Group, 1993. *Environmental Data Administration Plan*, Rev. 3. DOE/OR/21548-119. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. August.

44. U.S. Environmental Protection Agency, 1989. *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells*. EPA 600/4-89/034. National Water Well Association. Dublin, OH.

45. American Public Health Association, 1992. *Standard Methods For the Examination of Water and Wastewater*, Seventh Edition.

46. MK-Ferguson Company and Jacobs Engineering Group, 1992. *Dam Safety Operations Emergency Preparedness Plan*, Rev. 1. DOE/OR/21548-306. Prepared for the U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project. St. Charles, MO. December.

47. MK-Ferguson Company and Jacobs Engineering Group, 1994. *Wetlands Project Plan for COE Permit Application*, Rev. 0. DOE/OR/21548-437. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. January.

48. MK-Ferguson Company and Jacobs Engineering Group, 1994. *Remedial Action Work Plan for the Quarry Bulk Waste Management Program*, Rev. 1. DOE/OR/21548-419. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. January.

49. Kleeschulte, M.J., and J.L. Imes, 1993. *Geohydrology, Water Quality, and Simulation of Ground-Water Flow at the Weldon Spring Chemical Plant and Vicinity, St. Charles County, Missouri, 1987-90*. Open-File Report 93-648. Prepared in cooperation with the U.S. Department of Energy. Rolla, Missouri.

50. Fink, S.A., 1963. *Uptake of Nitroaromatic Compounds by Weldon Spring Soils*. A Thesis Presented to the Faculty of the Graduate School of the University of Missouri-Rolla in partial fulfillment of the requirements for the Degree of Master of Science in Civil Engineering.

51. MK-Ferguson Company and Jacobs Engineering Group, 1992. *Well Field Contingency Plan*, Rev. 0. DOE/OR/21548-340. Prepared for the U.S. Department of Energy, Oak Ridge Field Office. St. Charles, Missouri. November.

52. MacDonell, M.M., J.M. Peterson, and I.E. Joya. *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water in the Weldon Spring Quarry*. DOE/OR/21548-039. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. January 1989.§

53. Haroun, L.A., J. M. Peterson, M.M. MacDonell, and I. Hlohowskyj. *Baseline Risk Evaluation for Exposure to Bulk Wastes at the Weldon Spring Quarry, Weldon Spring, Missouri*. DOE/OR/21548-065. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. January 1990.§

54. MK-Ferguson Company and Jacobs Engineering Group. *Storm Water Runoff Sampling Plan*, Rev. 0. DOE/OR/21548-291. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, Missouri. May 1992.

55. U.S. Department of Energy. *Proposed Plan for Remedial Action at the Chemical Plant Area of the Weldon Spring Site*. DOE/OR/21548-160. November 1992.§

ASME NQA-1, *American Society of Mechanical Engineers, Nuclear Quality Assurance*

DOE ORDERS

5000.3B, *Occurrence Reporting and Processing of Information*
5400.1, *General Environmental Protection Program*
5400.3, *Hazardous and Mixed Waste Program*
5400.5, *Radiation Protection*
5480.1B, *Environment, Safety and Health Program for Department of Energy Operations*
5480.4, *Environmental Protection, Safety, and Health Protection Standards*
5482.1B, *Safety Analysis and Review System*
5700.6C, *Quality Assurance*
5820.2A, *Radioactive Waste Management*

REGULATIONS

10 CFR 1022, *Department of Energy, Compliance With Floodplain/Wetlands Environmental Review Requirements*
36 CFR Part 800.5, *Protection of Historic and Cultural Properties*
40 CFR Part 61, *National Emission Standards for Hazardous Air Pollutants*
40 CFR 761, *Polychlorinated Biphenyls, Manufacturing, Processing, Distribution in Commerce, and Use in Prohibitions*
40 CFR 761.125, *Requirements for PCB Spill Cleanup*

PROCEDURES

ES&H 3.1.7, *Noise Monitoring*

ES&H 4.1.4, *Quality Control Samples for Aqueous and Solid Matrices: Definitions, Identification Codes, and Collection Procedures*

ES&H 4.2.1, *Erosion Control Survey*

ES&H 4.2.3, *Embankment Survey*

ES&H 4.9.3, *Data Review Procedures for Surface Water, Groundwater, and Soils*

12 GLOSSARY, ACRONYMS, AND ABBREVIATIONS

12.1 Technical Terms

ABSORBED DOSE: The amount of energy absorbed in any material from incident radiation. Measured in rads, where 1 rad equals 100 ergs of energy absorbed in 1 gram of matter.

ACTIVITY: A measure of the rate at which radioactive material is undergoing radioactive decay; usually given in terms of the number of nuclear disintegrations occurring in a given quantity of material over a unit of time. The unit of activity is the curie (Ci) (see also BECQUEREL and CURIE).

ALARA: An acronym for "As Low as Reasonably Achievable." This refers to the U.S. Department of Energy goal of keeping releases of radioactive substances to the environment and exposures of humans to radiation as far below regulatory limits as "reasonably achievable."

ALLUVIAL AQUIFER: A subsurface zone, formed by the deposition of sediments by running water, capable of yielding usable quantities of groundwater to wells.

ALPHA PARTICLE: A positively charged particle emitted from the nucleus during the radioactive decay of certain radionuclides. It consists of two protons and two neutrons bound together; it is identical to the nucleus of a helium-4 atom.

BACKGROUND RADIATION: Radiation due to cosmic rays and radiation from the naturally radioactive elements in the surface of earth.

BEDROCK: A rock formation usually underlying one or more unconsolidated formations.

BECQUEREL: The SI unit for activity. 1 becquerel (Bq) = 1 disintegration/second = 2.703×10^{-11} curies.

BETA PARTICLE: A charged particle emitted from the nucleus of an atom, with a mass and charge equal in magnitude to that of the electron.

CHAIN-OF-CUSTODY FORM: A standardized form used in tracing the possession and handling of individual samples from the time of field collection through laboratory analysis.

COMMITTED EFFECTIVE DOSE EQUIVALENT: The total dose equivalent averaged throughout a tissue in the 50 years after intake of a radionuclide into the body.

CONTAMINATION: A foreign substance in or on the surfaces of soils, structures, areas, objects, or personnel.

COUNTING STATISTICS: Statistical analysis required to process the results of nuclear counting experiments and to make predictions about the expected precision of quantities derived from these measurements.

CURIE: A measure of the rate of radioactive decay. One curie (Ci) is equal to 37 billion disintegrations per second (3.7×10^{10} dps), which is equal to the decay rate of one gram of radium-226.

DAUGHTER: An element that results immediately from the disintegration of a radioactive element.

DECAY PRODUCTS: Isotopes that are formed by the radioactive decay of some other isotope. In the case of radium-226, for example, there are 10 successive decay products, ending in the stable isotope lead-206.

DERIVED CONCENTRATION GUIDE: Concentrations of radionuclides in water and air that could be continuously consumed or inhaled and not exceed an effective dose equivalent of 100 mrem/year.

DISCHARGE: In groundwater hydrology, the rate of flow (usually from a well or spring) at a given instant in terms of volume per unit of time.

DOSE: Total radiation delivered to a specific part of the body, or to the body as a whole; also called dose equivalent.

DOSE RATE: Dose or dose equivalent per unit of time (e.g., millirem per year) as it is being delivered to the body.

DOSIMETER: A device used in measuring radiation dose, such as a lithium fluoride (LiF) thermoluminescent detector (TLD).

EFFECTIVE DOSE EQUIVALENT: The proportion of the stochastic risk resulting from irradiation of a tissue to the total risk when the whole body is irradiated uniformly. A term used to express the amount of effective radiation when modifying factors have been considered, it is the product of absorbed dose (rads) multiplied by a quality factor and any other modifying factors. It is measured in rem (Roentgen Equivalent Man).

ERG: 1 ERG = 2.8×10^{-14} KWH

EXPOSURE PATHWAY: The route by which a contaminant or health hazard may enter and move through the environment or an individual.

EXPOSURE RADIATION: The amount of ionization produced in air by X-rays or gamma rays, measured in Roentgens (R).

GAMMA RADIATION: Penetrating high energy, short wave-length, electromagnetic radiation (similar to X-rays) emitted during radioactive decay. Gamma rays are very penetrating and can be attenuated only by dense materials such as lead.

GROSS ALPHA: Measurement of all alpha-emitting radionuclides in a sample.

GROSS BETA: Measurement of all beta-emitting radionuclides in a sample.

HALF-LIFE: The time it takes for half the atoms of a quantity of a particular radioactive element to decay into another form. Half-lives of different isotopes vary from millionths of a second or less to billions of years.

HECTARE: A unit of area in the metric system equal to 10,000 square meters. It is approximately 2.5 acres.

HYDROLOGIC: Pertaining to study of the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

ISOTOPE: Nuclides having the same atomic number but different mass numbers.

LLD: Lower limit of detection.

MDA: Minimum detectable amount.

NATURAL URANIUM: A naturally occurring radioactive element that consists of 99.2830% uranium-238, 0.7110% uranium-235 and 0.0054% uranium-234 by weight.

NUCLIDE: A general term referring to isotopes of the chemical elements, both stable and unstable.

PERCHED LENSE: A small, localized water-saturated zone of subsurface material surrounded by unsaturated material.

RAD: A unit of absorbed dose; acronym for radiation absorbed dose.

RADIATION: A very general term that covers many forms of particles and energy, from sunlight and radiowaves to the energy that is released from inside an atom. Radiation can be in the form of electromagnetic waves (gamma rays, X-rays) or particles (alpha particles, beta particles, protons, neutrons).

RADIONUCLIDE: An unstable nuclide that undergoes radioactive decay.

RAFFINATE: A waste product from a refining process, i.e., that portion of a treated liquid mixture that is not dissolved and not removed by a selective solvent.

REM (Roentgen Equivalent Man): A quantity used in radiation protection to express the effective dose equivalent for all forms of ionizing radiation. A rem is the product of the absorbed dose in rads and factors related to relative biological effectiveness.

SI: International System of Units.

SIEVERT: The SI unit used to express the effective dose equivalent for all forms of ionizing radiation. 1 Sv = 100 rem

STOCHASTIC: "Stochastic" effects are those for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose, without a threshold.

WORKING LEVEL: Any combination of radon-222 decay products in 1 liter of air that will result in the ultimate emission of 0.21 erg of alpha energy is defined as 1 WL. It is based on the 0.21 erg of alpha energy that would be emitted by the decay products of 100 pCi of Ra-222 in 1 liter of air, where the decay products are in radioactive equilibrium with the parent.

WORKING LEVEL MONTH: The product of WL and duration of exposure, normalized to a 1-month exposure period.

X-RAY: Penetrating electromagnetic radiation having a wave length that is much shorter than that of visible light. It is customary to refer to rays originating in the nucleus of an atom as gamma rays and to those originating in the electron field of the atom as X-rays.

12.2 Acronyms and Abbreviations

No abbreviations for common units of measure or chemical elements and compounds are included in this list. Some less common units of measure, such *pCi* and *μCi* are included.

ACM	asbestos-containing materials
AEC	Atomic Energy Commission
AHERA	Asbestos Hazard and Emergency Response Act
ALARA	as low as reasonably achievable
ANL	Argonne National Laboratory
ARAR	applicable and/or relevant and appropriate requirements
ASME	American Society of Mechanical Engineers
BA	Baseline Assessment for the Chemical Plant Area of the Weldon Spring Site
BOD	Biochemical Oxygen Demand
Bq	becquerel
CAA	Clean Air Act
CEDE	Committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Ci	curie
CLP	Contract Laboratory Program
CM&O	Construction Management and Operations
COD	chemical oxygen demand
CONOPS	Conduct of Operations
CWA	Clean Water Act
CX	categorical exclusion
DCG	Derived Concentration Guideline
DL/2	detection limit
DNT	dinitrotoluene
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DQO	data quality objectives
EA	Environmental Assessment
EDAP	Environmental Data Administration Plan

EDE	effective dose equivalent
EE/CA	engineering evaluation/cost analysis
EIS	Environmental Impact Statement
EMP	Environmental Monitoring Plan
EPA	Environmental Protection Agency
EPA	U.S. Environmental Protection Agency
EPPIP	Environmental Protection Program Implementation Plan
EQA	Environmental Quality Assurance
EQAPjP	Environmental Quality Assurance Project Plan
ES&H	Environmental Safety and Health
FERC	Federal Energy Regulatory Commission
FFA	Federal Facility Agreement
FHHS	Francis Howell High School
FP	Fire Protection
FS	Feasibility Study for the Remedial Action at the Chemical Plant Area of the Weldon Spring Site
HAP	hazardous air pollutants
HMWM	Hazardous Materials Waste Management
HP	Health Physics
HPO	Missouri Department of Natural Resources Historical Preservation Officer
HQ	Headquarters
HSL	Hazardous Substance List
HVAC	heating, ventilating, and air conditioning
IH	Industrial Hygiene
IS	Industrial Safety
LDR	Land Disposal Restrictions
LLD	lower limit of detection
MACT	Maximum Available Control Technology
MCL	maximum contaminant level (Safe Drinking Water Act)
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDNR	Missouri Department of Natural Resources
MDOC	Missouri Department of Conservation
MHTC	Missouri Highway Transportation Commission
MSA	material staging area

msl	mean sea level
mSv	millisievert
NAAQS	national ambient air quality standards
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
PCB	polychlorinated biphenyl
pCi	picocurie
PCM	phase contrast microscopy
PMC	Project Management Contractor
PP	Proposed Plan for Remedial Action and the Chemical Plant Area of the Weldon Spring Site
ppm	parts per million
PTI	Project Training and Improvement
PVC	polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
QA	Quality Assurance
QAMS	Quality Assurance Management Staff
QAPjP	Quality Assurance Project Plan
QWTP	quarry water treatment plant
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SI	Saturation Indexes
SIC	Standard Industrial Classification
SOP	Standard Operating Procedures
SWATS	Site Wide Audit Tracking System
SWTP	site water treatment plant
TBP	tributyl phosphate

TC	toxicity characteristic
TDS	total dissolved solids
TEM	transmission electron microscopy
TLD	thermoluminescent dosimeter
TNB	trinitrobenzene
TND	dinitrotoluene
TNT	trinitrotoluene
tpy	tons per year
TSA	temporary storage area
TSCA	Toxic Substance Control Act
TSS	total suspended solid
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compounds
WITS	Waste Inventory Tracking System
WLM	Working Level Monitor
WPC	Water Pollution Control
WSCP	Weldon Spring Chemical Plant
WSQ	Weldon Spring Quarry
WSRP	Weldon Spring raffinate pits
WSSRAP	Weldon Spring Site Remedial Action Project
WSUFMP	Weldon Spring Uranium Feed Materials Plant
l	liter
mg	milligram
mg/l	milligrams per liter
μCi	microcurie
μg/l	micrograms per liter

APPENDIX A
Annual Averages for Groundwater, Surface Water, and Springs, 1993

Appendix A is a presentation of the annual averages, maximums, and minimums for all 1993 monitoring locations for groundwater, surface water, and springs. All nondetected values are expressed as less than (<) the analtyical detection limit. Asterisk indicates where unrepresentative data were excluded from the dataset prior to performing the summary calculations. Criteria for removing these outliers are discussed in Sections 7.3.3 and 7.3.4.

TABLE A-1 Anion Concentrations for Groundwater, 1993

	Bromide mg/l				Chloride mg/l				Nitrate-N mg/l				Nitrite-N mg/l				Sulfate mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1002	<0.380	ND	ND	4/4	19.0	15.2	21.6	0/4	4.05	1.80	6.60	0/6	<0.100	ND	ND	4/4	73.2	61.8	81.3	0/9
GW-1004									1.18	ND	4.20	1/4					215	81.1	337	0/12
GW-1005	<0.380	ND	ND	4/4	25.2	19.3	32.5	0/4	<0.167	ND	0.120	5/6	<0.100	ND	ND	4/4	167	129	193	0/9
GW-1006									0.400	0.160	0.640	0/2					430	386	474	0/2
GW-1007									<0.100	ND	0.110	1/2					118	73.7	163	0/2
GW-1008									<0.100	ND	ND	2/2					245	202	268	0/4
GW-1009									<0.133	ND	0.100	2/3					245	217	263	0/3
GW-1010									<0.100	ND	0.170	2/3					3.26	ND	12.0	2/4
GW-1011									<0.100	ND	ND	3/3					30.7	27.1	34.0	0/4
GW-1012									0.870	0.760	1.00	0/4					60.9	49.5	75.4	0/6
GW-1013	<0.380	ND	ND	2/2	21.8	15.0	28.6	0/2	<0.100	ND	0.100	3/4	<0.100	ND	ND	2/2	94.2	76.5	101	0/4
GW-1014	<0.337	ND	ND	3/3	22.6	20.0	26.3	0/3	<0.100	ND	0.130	3/4	<0.100	ND	ND	3/3	99.8	96.0	103	0/4
GW-1015									0.355	ND	1.10	1/4					186	109	262	0/6
GW-1016									0.193	ND	0.500	1/4					149	77.9	215	0/6
GW-1017									<0.350	ND	0.260	1/2					0.496	0.380	0.610	0/2
GW-1018	<0.380	ND	ND	3/3	21.7	17.9	26.7	0/3	<0.100	ND	0.100	1/3	<0.100	ND	ND	2/2	78.3	63.9	93.2	0/3
GW-1019	<0.380	ND	ND	3/3	8.80	8.10	9.90	0/3	<0.073	ND	0.100	2/3	<0.100	ND	ND	2/2	1.39	0.340	3.40	0/3
GW-1020									<0.300	ND	0.120	1/2					39.6	11.2	82.1	0/3
GW-1021	<0.315	ND	ND	2/2	10.8	10.0	11.5	0/2	0.330	ND	0.610	1/2	<0.100	ND	ND	2/2	0.835	0.370	1.30	0/2
GW-1022	<0.337	ND	ND	3/3	10.1	9.00	11.3	0/3	<0.100	ND	0.130	1/3	<0.100	ND	ND	2/2	1.75	ND	5.00	2/3

TABLE A-1 Anion Concentrations for Groundwater, 1993 (Continued)

	Bromide mg/l				Chloride mg/l				Nitrate-N mg/l				Nitrite-N mg/l				Sulfate mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1023									0.390	ND	0.680	1/2					5.95	5.60	6.30	0/2
GW-1024									<0.100	ND	0.140	1/2					8.87	0.830	16.9	0/2
GW-1026									<0.100	ND	ND	4/4					0.790	0.700	0.900	0/6
GW-1027									0.317	0.120	0.500	0/3					99.7	79.2	113	0/7
GW-1028	<0.380	ND	ND	2/2	8.95	8.80	9.10	0/2	0.283	0.110	0.620	0/3	<0.100	ND	ND	2/2	63.8	61.9	65.7	0/3
GW-1029									<0.133	ND	ND	3/3					65.5	34.3	73.0	0/7
GW-1030									0.413	0.220	0.530	0/3					112	70.0	145	0/9
GW-1031									0.148	ND	0.370	2/4					31.9	28.0	35.0	0/4
GW-1032	<0.380	ND	ND	2/2	38.9	38.1	39.6	0/2	<0.133	ND	0.210	2/3	<0.100	ND	ND	2/2	215	139	254	0/3
GW-1033	<0.380	ND	ND	2/2	6.60	5.70	7.50	0/2	<0.100	ND	ND	2/2	<0.100	ND	ND	2/2	11.4	9.90	12.9	0/2
GW-1034	<0.380	ND	ND	4/4	18.1	17.4	19.0	0/4	1.44	0.160	2.70	0/4	<0.100	ND	ND	4/4	76.3	44.1	99.3	0/5
GW-1035									<0.100	ND	0.160	2/3					33.4	28.0	38.6	0/4
GW-1036									0.186	ND	0.310	2/5					61.0	55.5	70.8	0/5
GW-1037									0.186	ND	0.340	2/5					42.1	14.2	72.1	0/5
GW-1038									0.136	ND	0.260	2/5					45.2	2.89	62.9	0/5
GW-1039									0.138	ND	0.220	1/5					48.0	37.7	56.6	0/5
GW-2001	<2.28	ND	ND	2/2	6.30	6.10	6.50	0/2	53.9	29.2	97.0	0/3	<0.100	ND	ND	2/2	9.63	9.00	9.90	0/4
GW-2002	<3.94	ND	ND	2/2	9.20	8.00	10.4	0/2	235	148	308	0/4	<0.100	ND	ND	2/2	116	89.5	139	0/4
GW-2003	<5.65	ND	ND	2/2	10.8	10.5	11.1	0/2	461	271	786	0/4	<0.100	ND	ND	2/2	127	100	144	0/4

m:\users\joanne\aser93\gw93ions

TABLE A-1 Anion Concentrations for Groundwater, 1993 (Continued)

	Bromide mg/l				Chloride mg/l				Nitrate-N mg/l				Nitrite-N mg/l				Sulfate mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2004	<0.380	ND	ND	4/4	2.00	1.70	2.30	0/4	0.750	0.570	0.880	0/4	<0.100	ND	ND	4/4	1.78	1.70	2.00	0/4
GW-2005	<3.00	ND	ND	4/4	3.50	2.90	4.00	0/4	59.6	33.4	71.8	0/4	<0.088	ND	ND	4/4	20.2	14.6	23.1	0/4
GW-2006	<0.473	ND	0.870	3/4	334	323	350	0/4	5.83	5.20	6.70	0/4	<0.088	ND	ND	4/4	43.5	34.5	70.0	0/4
GW-2007	<0.380	ND	ND	4/4	1.48	1.10	1.80	0/4	0.096	ND	0.260	3/4	<0.088	ND	ND	4/4	15.1	14.8	15.5	0/4
GW-2008	<0.380	ND	ND	4/4	131	123	140	0/4	2.58	1.70	3.60	0/4	<0.088	ND	ND	4/4	38.5	36.0	40.5	0/4
GW-2009	<0.380	ND	0.440	3/4	17.3	15.4	18.7	0/4	0.958	0.290	1.90	0/4	<0.138	ND	ND	4/4	110	102	121	0/4
GW-2010	<0.380	ND	ND	4/4	55.2	49.0	58.3	0/4	1.13	0.930	1.50	0/4	<0.088	ND	ND	4/4	35.4	27.8	41.0	0/4
GW-2011	<0.380	ND	ND	4/4	3.95	3.70	4.20	0/4	5.18	5.10	5.30	0/4	<0.100	ND	ND	4/4	13.1	12.6	13.5	0/4
GW-2012	<0.380	ND	ND	4/4	32.4	22.2	48.3	0/4	0.628	0.530	0.750	0/4	<0.078	ND	ND	4/4	65.2	63.4	66.3	0/4
GW-2013	<0.380	ND	ND	4/4	3.18	2.50	4.10	0/4	0.603	0.350	1.00	0/4	<0.078	ND	ND	4/4	9.50	7.50	13.0	0/4
GW-2014	0.436	ND	0.560	1/4	25.9	23.3	29.0	0/4	1.83	1.20	2.90	0/4	<0.078	ND	ND	4/4	33.6	32.5	36.8	0/4
GW-2015	<0.380	ND	ND	4/4	1.93	1.20	2.60	0/4	0.498	0.200	1.20	0/4	<0.100	ND	ND	4/4	103	86.4	119	0/4
GW-2017	<0.380	ND	ND	4/4	16.9	15.4	17.7	0/4	0.193	ND	0.380	2/4	<0.078	ND	ND	4/4	768	671	846	0/4
GW-2018	<0.380	ND	ND	4/4	7.65	7.20	8.10	0/4	0.610	0.390	0.960	0/4	<0.078	ND	ND	4/4	9.85	9.20	10.7	0/4
GW-2019	<0.380	ND	ND	4/4	1.93	1.40	2.40	0/4	0.295	ND	0.780	2/4	<0.100	ND	ND	4/4	28.6	18.6	36.9	0/4
GW-2020	0.457	0.420	0.480	0/3	20.4	19.2	22.1	0/3	0.773	0.670	0.850	0/3	<0.100	ND	ND	3/3	126	122	128	0/3
GW-2021	<0.380	ND	ND	4/4	1.55	0.880	1.90	0/4	0.193	ND	0.440	2/4	<0.100	ND	ND	4/4	13.6	12.5	15.1	0/4
GW-2022	<0.380	ND	ND	4/4	1.64	0.870	2.20	0/4	<0.100	ND	ND	4/4	<0.100	ND	ND	4/4	14.1	14.0	14.2	0/4
GW-2023	<0.348	ND	ND	4/4	1.29	0.970	1.60	0/4	0.100	ND	0.290	3/4	<0.078	ND	ND	4/4	14.3	13.4	14.9	0/4

TABLE A-1 Anion Concentrations for Groundwater, 1993 (Continued)

	Bromide mg/l				Chloride mg/l				Nitrate-N mg/l				Nitrite-N mg/l				Sulfate mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2024	<0.348	ND	ND	4/4	2.13	1.70	2.60	0/4	0.085	ND	0.230	3/4	<0.078	ND	ND	4/4	29.7	28.1	30.7	0/4
GW-2025	<0.380	ND	ND	4/4	1.78	1.40	2.50	0/4	<0.088	ND	0.120	3/4	<0.088	ND	ND	4/4	15.2	13.9	16.8	0/4
GW-2026	<0.348	ND	ND	4/4	2.08	1.50	2.60	0/4	<0.080	ND	0.100	2/4	<0.078	ND	ND	4/4	16.7	15.0	20.1	0/4
GW-2027	<0.348	ND	ND	4/4	1.63	1.20	2.00	0/4	0.158	ND	0.310	1/4	<0.078	ND	ND	4/4	11.2	10.4	12.0	0/4
GW-2028	<0.380	ND	ND	4/4	2.35	1.70	3.10	0/4	0.130	ND	0.400	2/4	<0.078	ND	ND	4/4	127	121	133	0/4
GW-2029	<0.380	ND	ND	4/4	1.68	1.40	1.90	0/4	<0.188	ND	ND	4/4	<0.188	ND	ND	4/4	22.1	19.4	23.8	0/4
GW-2030	<0.348	ND	0.380	3/4	30.1	26.3	33.8	0/4	1.21	0.890	1.70	0/4	<0.100	ND	ND	4/4	47.4	46.1	48.4	0/4
GW-2032	<2.84	ND	ND	4/4	18.8	17.3	20.9	0/4	85.4	61.4	112	0/4	<0.078	ND	ND	4/4	53.6	52.6	54.9	0/4
GW-2033	<0.348	ND	0.480	2/4	5.43	3.60	8.60	0/4	0.858	0.460	1.50	0/4	<0.100	ND	ND	4/4	21.2	17.2	26.8	0/4
GW-2034	<0.380	ND	ND	4/4	18.8	17.6	19.8	0/4	2.15	0.800	3.50	0/4	<0.080	ND	ND	4/4	523	447	594	0/4
GW-2035	<0.380	ND	ND	1/1	1.90	1.90	—	0/1	0.758	0.300	1.70	0/5	<0.100	ND	ND	1/1	2.10	2.00	2.20	0/5
GW-2036	<0.380	ND	ND	1/1	1.70	1.70	—	0/1	3.74	2.70	5.30	0/5	<0.100	ND	ND	1/1	4.40	4.30	4.50	0/5
GW-2037	<18.80	ND	ND	1/1	47.0	47.0	—	0/1	419	274	560	0/5	0.530	0.530	—	0/1	156	154	159	0/5
GW-2038	<18.80	ND	ND	1/1	39.6	39.6	--	0/1	1392	1250	1670	0/5	0.170	0.170	--	0/1	88.2	77.9	94.2	0/5
GW-2039	<9.80	ND	ND	1/1	31.8	31.8	--	0/1	66.1	37.1	96.6	0/5	<0.100	ND	ND	1/1	41.9	37.7	48.4	0/5
GW-2040	<7.50	ND	ND	1/1	4.90	4.90	--	0/1	290	215	407	0/5	<0.100	ND	ND	1/1	15.5	12.6	21.7	0/5
GW-2041	<18.80	ND	ND	1/1	19.7	19.7	---	0/1	1642	746	3530	0/5	0.620	0.620	--	0/1	113	87.4	141	0/5
GW-2042	<0.380	ND	ND	1/1	6.70	6.70	---	0/1	8.74	7.40	12.1	0/5	<0.100	ND	ND	1/1	23.6	22.4	24.2	0/5
GW-2043	<0.380	ND	ND	1/1	6.30	6.30	---	0/1	5.54	4.50	7.40	0/5	<0.100	ND	ND	1/1	16.1	14.1	20.1	0/5

TABLE A-1 Anion Concentrations for Groundwater, 1993 (Continued)

	Bromide mg/l				Chloride mg/l				Nitrate-N mg/l				Nitrite-N mg/l				Sulfate mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-3003	<3.15	ND	ND	2/2	11.8	11.0	12.5	0/2	346	286	406	0/2	<0.100	ND	ND	2/2	188	186	189	0/2
GW-3006	<0.380	ND	ND	2/2	2.00	1.80	2.20	0/2	0.165	ND	0.280	1/2	<0.100	ND	ND	2/2	38.7	21.0	56.3	0/2
GW-3008	<28.2	ND	ND	2/2	19.6	18.0	21.1	0/2	785	750	819	0/2	<0.100	ND	ND	2/2	86.0	84.0	87.9	0/2
GW-3009	<5.65	ND	ND	2/2	7.55	5.20	9.90	0/2	318	145	491	0/2	0.335	0.280	0.390	0/2	62.8	52.6	73.0	0/2
GW-3019	<1.283	ND	ND	4/4	1.01	ND	1.30	1/4	0.155	ND	0.270	2/4	<0.100	ND	ND	4/4	6.53*	6.20	7.00	0/3
GW-3023	<1.985	ND	ND	4/4	14.6	13.0	15.2	0/4	258	197	288	0/4	0.748	0.680	0.800	0/4	312	308	318	0/4
GW-4001	<5.65	ND	ND	2/2	4.75	4.70	4.80	0/2	36.1	34.2	37.9	0/2	<0.100	ND	ND	2/2	62.1	61.2	62.9	0/2
GW-4002	<0.380	ND	ND	2/2	3.00	3.00	—	0/2	4.60	1.40	7.79	0/2	<0.100	ND	ND	2/2	23.2	21.1	25.3	0/2
GW-4003	<0.380	ND	ND	2/2	6.20	6.20	—	0/2	0.785	0.710	0.860	0/2	<0.100	ND	ND	2/2	32.3	31.3	33.2	0/2
GW-4004	<0.380	ND	ND	2/2	3.90	3.80	4.00	0/2	1.10	1.10	—	0/2	<0.100	ND	ND	2/2	21.9	21.3	22.5	0/2
GW-4005	<0.380	ND	ND	2/2	7.20	7.00	7.40	0/2	2.00	1.40	2.60	0/2	<0.100	ND	ND	2/2	19.1	18.1	20.0	0/2
GW-4006	<0.380	ND	ND	2/2	2.70	2.60	2.80	0/2	6.05	5.30	6.80	0/2	<0.100	ND	ND	2/2	26.4	25.7	27.1	0/2
GW-4007	<0.380	ND	ND	2/2	1.10	1.10	—	0/2	0.110	ND	0.170	1/2	<0.100	ND	ND	2/2	12.0	11.5	12.4	0/2
GW-4008	<0.380	ND	ND	2/2	2.05	1.40	2.70	0/2	<0.100	ND	0.150	1/2	<0.100	ND	ND	2/2	14.1	13.8	14.3	0/2
GW-4009	<0.380	ND	ND	2/2	1.70	1.40	2.00	0/2	0.110	ND	0.170	1/2	<0.100	ND	ND	2/2	16.3	16.0	16.5	0/2
GW-4010	<0.380	ND	ND	2/2	1.95	1.90	2.00	0/2	0.285	0.110	0.460	0/2	<0.100	ND	ND	2/2	22.7	22.4	22.9	0/2
GW-4011	<5.65	ND	ND	2/2	6.65	6.50	6.80	0/2	55.8	55.5	56.1	0/2	<0.100	ND	ND	2/2	62.7	62.5	62.8	0/2
GW-4012	<0.380	ND	ND	2/2	2.35	2.20	2.50	0/2	0.295	ND	0.540	1/2	<0.100	ND	ND	2/2	46.4	44.7	48.1	0/2
GW-4013	<3.80	ND	ND	2/2	6.55	6.30	6.80	0/2	63.4*	63.4	—	0/1	<0.100	ND	ND	2/2	42.6	40.5	44.7	0/2

TABLE A-1 Anion Concentrations for Groundwater, 1993 (Continued)

	Bromide mg/l				Chloride mg/l				Nitrate-N mg/l				Nitrite-N mg/l				Sulfate mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-4014	<0.380	ND	ND	2/2	5.46	5.10	5.80	0/2	4.85	4.40	5.30	0/2	<0.100	ND	ND	2/2	26.9	26.1	27.6	0/2
GW-4015	<0.380	ND	ND	2/2	4.70	3.60	5.80	0/2	2.35	1.60	3.10	0/2	<0.100	ND	ND	2/2	14.4	9.50	19.2	0/2
GW-4016	<0.380	ND	ND	2/2	1.95	1.60	2.30	0/2	<0.250*	ND	ND	1/1	<50.1	ND	ND	2/2	13.7	13.2	14.2	0/2
GW-4017	<0.380	ND	ND	2/2	2.30	2.30	---	0/2	0.450	0.430	0.470	0/2	<0.100	ND	ND	2/2	7.20	6.70	7.70	0/2
GW-4018	<0.380	ND	ND	2/2	16.6	14.6	18.4	0/2	3.50	2.70	4.30	0/2	<0.100	ND	ND	2/2	7.15	7.00	7.30	0/2
GW-4019	<0.380	ND	ND	2/2	1.55	1.50	1.60	0/2	0.253	0.146	0.360	0/2	<0.100	ND	ND	2/2	8.10	8.09	8.10	0/2
GW-4020	<0.380	ND	ND	2/2	17.8	14.3	21.3	0/2	0.305	ND	0.560	1/2	<0.100	ND	ND	2/2	139	138	139	0/2
GW-4021	<0.380*	ND	ND	1/1	2.10*	2.10	---	0/1	0.250*	0.250	---	0/1	<0.100 *	ND	ND	1/1	258*	258	---	0/1
GW-4022	<0.348	ND	ND	4/4	5.88	4.90	6.90	0/4	0.366	0.110	0.560	0/6	<0.073	ND	ND	3/3	33.4	28.5	36.1	0/4
GW-4023	<0.380	ND	ND	2/2	12.9	12.7	13.0	0/2	4.85	4.30	5.40	0/2	<0.100	ND	ND	2/2	71.0	70.3	71.7	0/2
GW-FINW									<0.060	ND	ND	2/2					61.4	49.0	73.8	0/2
GW-PW02	<0.380	ND	ND	3/3	16.7	13.5	18.5	0/3	<0.065	ND	ND	4/4	<0.073	ND	ND	3/3	62.5	48.4	76.9	0/4
GW-PW03									<0.270	ND	ND	2/2					70.0	59.8	80.2	0/2
GW-PW04									<0.100	ND	ND	1/1					88.7	88.7	---	0/1
GW-PW05									<0.070	ND	ND	2/2					61.7	49.1	74.3	0/2
GW-PW06									<0.100	ND	ND	1/1					93.8	93.8	---	0/1
GW-PW07									<0.100	ND	ND	1/1					72.8	72.8	---	0/1
GW-PW08									<0.100	ND	ND	1/1					46.4	46.4	---	0/1
GW-PW09	<0.380	ND	ND	3/3	6.37	5.30	7.50	0/3	<0.065	ND	0.075	3/4	<0.073	ND	ND	3/3	38.9	37.5	40.7	0/4

TABLE A-1 Anion Concentrations for Groundwater, 1993 (Continued)

	Bromide mg/l				Chloride mg/l				Nitrate-N mg/l				Nitrite-N mg/l				Sulfate mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-RAWW									<0.150	ND	ND	2/2					60.6	49.1	72.1	0/2
GW-RMW1	<0.380	ND	ND	2/2	10.2	6.20	14.2	0/2	<0.100	ND	ND	2/2	<0.100	ND	ND	2/2	23.2	21.0	26.4	0/2
GW-RMW2	<0.315	ND	ND	2/2	7.80	7.50	8.09	0/2	<0.100	ND	0.130	1/2	<0.100	ND	ND	2/2	20.2	19.3	21.0	0/2
GW-RMW3									<0.150	ND	ND	2/2					68.6	38.4	98.8	0/2
GW-RMW4									0.176	ND	0.250	1/2					16.6	16.1	17.1	0/2

TABLE A-2 Alkalinity, Phosphorous, and Silica Concentrations for Groundwater, 1993

	Alkalinity mg/l				Phosphorous mg/l				Silica, Dissolved mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1002	316	300	340	0/9	0.074	ND	0.140	1/4	12.8	5.30	23.6	0/4
GW-1004	288	220	450	0/12								
GW-1005	245	215	280	0/9	0.048	ND	0.110	1/4	14.2	9.00	21.9	0/4
GW-1006	420	410	430	0/2								
GW-1007	593	560	625	0/2								
GW-1008	380	370	400	0/4								
GW-1009	423	410	430	0/3								
GW-1010	368	330	412	0/4								
GW-1011	264	210	380	0/4								
GW-1012	506	490	530	0/6								
GW-1013	388	350	420	0/4	0.080	0.050	0.110	0/2	18.3	12.8	23.8	0/2
GW-1014	413	360	460	0/4	0.057	0.050	0.060	0/3	24.9	23.7	25.7	0/3
GW-1015	379	355	400	0/6								
GW-1016	365	350	390	0/6								
GW-1017	675	650	700	0/2								
GW-1018	460	420	500	0/3	0.747	0.410	1.40	0/3	23.9	19.9	28.7	0/3
GW-1019	457	440	480	0/3	0.490	0.070	0.880	0/3	18.3	12.2	21.3	0/3
GW-1020	423	360	460	0/3								
GW-1021	465	440	490	0/2	0.965	0.930	1.00	0/2	24.4	16.0	32.8	0/2

TABLE A-2 Alkalinity, Phosphorous, and Silica Concentrations for Groundwater, 1993 (Continued)

	Alkalinity mg/l				Phosphorous mg/l				Silica, Dissolved mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1022	440	410	480	0/3	0.687	0.170	1.10	0/3	24.8	8.40	39.6	0/3
GW-1023	455	440	470	0/2								
GW-1024	375	330	420	0/2								
GW-1026	387	380	400	0/6								
GW-1027	420	350	470	0/7								
GW-1028	413	400	430	0/3	0.080	0.080	—	0/2	22.4	20.0	24.7	0/2
GW-1029	381	370	390	0/7								
GW-1030	464	420	550	0/9								
GW-1031	355	350	360	0/4								
GW-1032	337	320	350	0/3	0.050	0.040	0.060	0/2	15.8	13.7	17.9	0/2
GW-1033	453	445	460	0/2	1.02	0.930	1.10	0/2	10.3	8.30	12.3	0/2
GW-1034	454	420	500	0/6	0.094	0.060	0.140	0/4	23.1	18.2	27.2	0/4
GW-1035	228	220	250	0/4								
GW-1036	580	510	700	0/6								
GW-1037	584	500	660	0/5								
GW-1038	476	460	500	0/5								
GW-1039	552	540	560	0/5								
GW-2001	328	320	340	0/4	0.038	ND	0.050	1/2	8.80	8.40	9.20	0/2
GW-2002	313	290	330	0/4	0.038	ND	0.050	1/2	13.7	12.8	14.6	0/2

TABLE A-2 Alkalinity, Phosphorous, and Silica Concentrations for Groundwater, 1993 (Continued)

	Alkalinity mg/l				Phosphorous mg/l				Silica, Dissolved mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2003	275	260	280	0/4	0.055	0.050	0.060	0/2	11.8	11.4	12.1	0/2
GW-2004	350	340	360	0/4	0.088	0.040	0.160	0/4	11.4	10.2	13.5	0/4
GW-2005	279	270	290	0/4	0.069	ND	0.130	1/4	7.58	4.10	12.5	0/4
GW-2006	311	310	315	0/4	0.129	ND	0.240	1/4	9.03	5.70	12.0	0/4
GW-2007	320	310	340	0/4	0.061	ND	0.120	1/4	7.98	2.60	14.5	0/4
GW-2008	305	290	320	0/4	0.269	ND	0.980	1/4	13.7	10.2	20.1	0/4
GW-2009	420*	390	440	0/3	0.083	0.050	0.160	0/4	10.1	5.60	13.9	0/4
GW-2010	335	270	360	0/4	0.066	0.030	0.100	0/4	11.7	8.80	13.4	0/4
GW-2011	275	260	280	0/4	0.051	ND	0.100	1/4	8.18	5.90	9.70	0/4
GW-2012	360	350	370	0/4	0.216	0.060	0.400	0/4	19.3	10.2	23.9	0/4
GW-2013	513	490	550	0/4	0.135	0.060	0.310	0/4	17.3	9.40	22.5	0/4
GW-2014	496	475	510	0/4	0.068	0.040	0.120	0/4	14.1	10.2	22.6	0/4
GW-2015	433	420	440	0/4	0.051	ND	0.110	1/4	9.63	7.30	12.2	0/4
GW-2017	383	375	390	0/4	0.082	0.057	0.130	0/4	12.6	8.10	20.8	0/4
GW-2018	425	410	440	0/4	0.051	ND	0.110	1/4	10.2	5.90	13.6	0/4
GW-2019	378	370	390	0/4	0.140	0.090	0.210	0/4	8.78	6.10	12.1	0/4
GW-2020	402	400	405	0/3	0.106	0.029	0.180	0/3	15.7	14.7	17.2	0/3
GW-2021	380	370	390	0/4	0.136	0.050	0.240	0/4	9.63	6.80	11.9	0/4
GW-2022	333	330	340	0/4	0.070	0.029	0.100	0/4	9.23	8.60	10.0	0/4

TABLE A-2 Alkalinity, Phosphorous, and Silica Concentrations for Groundwater, 1993 (Continued)

	Alkalinity mg/l				Phosphorous mg/l				Silica, Dissolved mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2023	227*	220	240	0/3	0.133	0.080	0.190	0/4	11.9	7.90	20.1	0/4
GW-2024	310	300	320	0/4	0.090	ND	0.210	1/4	8.47*	7.20	9.90	0/3
GW-2025	275*	270	280	0/2	0.071	ND	0.160	1/4	9.93	9.10	11.3	0/4
GW-2026	308	290	340	0/4	0.063	ND	0.120	1/4	8.25	6.00	9.60	0/4
GW-2027	256	250	260	0/4	0.056	ND	0.100	1/4	8.68	7.60	10.5	0/4
GW-2028	466	460	480	0/4	0.110	0.060	0.250	0/4	7.98	4.60	9.50	0/4
GW-2029	333	330	340	0/4	0.095	0.050	0.190	0/4	10.8	6.90	13.8	0/4
GW-2030	450	440	460	0/4	0.100	0.030	0.170	0/4	11.8	8.80	14.4	0/4
GW-2032	420	400	450	0/4	0.173	ND	0.460	1/4	10.7	4.90	12.9	0/4
GW-2033	495	400	550	0/4	0.090	0.047	0.130	0/4	17.2	14.6	20.7	0/4
GW-2034	430	410	450	0/4	0.185	0.050	0.310	0/4	12.0	9.10	16.0	0/4
GW-2035	154	32.0	190	0/5	0.120	0.120	—	0/1	8.50	8.50	—	0/1
GW-2036	308	300	320	0/5	0.110	0.110	—	0/1	9.90	9.90	—	0/1
GW-2037	254	240	270	0/5	0.070	0.070	—	0/1	12.5	12.5	—	0/1
GW-2038	206	190	220	0/5	0.080	0.080	—	0/1	10.5	10.5	—	0/1
GW-2039	382	350	410	0/5	0.130	0.130	—	0/1	15.9	15.9	—	0/1
GW-2040	299	250	350	0/5	<0.050	ND	ND	1/1	11.6	11.6	—	0/1
GW-2041	332	320	340	0/5	0.080	0.080	—	0/1	10.6	10.6	—	0/1
GW-2042	483	470	500	0/5	<0.050	ND	ND	1/1	11.0	11.0	—	0/1

TABLE A-2 Alkalinity, Phosphorous, and Silica Concentrations for Groundwater, 1993 (Continued)

	Alkalinity mg/l				Phosphorous mg/l				Silica, Dissolved mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2043	405	390	420	0/5	<0.050	ND	ND	1/1	9.30	9.30	---	0/1
GW-3003	316	310	322	0/2	0.043	ND	0.060	1/2	7.85	6.40	9.30	0/2
GW-3006	430	390	470	0/2	0.040	ND	0.070	1/2	10.9	10.1	11.7	0/2
GW-3008	188	185	190	0/2	0.055	0.020	0.090	0/2	13.3	13.1	13.5	0/2
GW-3009	175	160	190	0/2	0.065	0.030	0.080	0/2	12.3	6.60	17.9	0/2
GW-3019	265	250	280	0/4	0.113	0.073	0.150	0/4	10.8	9.10	12.4	0/4
GW-3023	278	275	280	0/4	0.080	0.020	0.110	0/4	9.18	4.50	11.4	0/4
GW-4001	203	200	205	0/2	<0.035	ND	ND	2/2	10.2	8.60	11.7	0/2
GW-4002	210	190	230	0/2	<0.035	ND	0.040	1/2	6.20	5.00	7.40	0/2
GW-4003	270	260	280	0/2	0.078	ND	0.130	1/2	8.60	7.40	9.80	0/2
GW-4004	185	180	190	0/2	0.121	0.102	0.140	0/2	9.55	9.40	9.70	0/2
GW-4005	220	210	230	0/2	0.095	0.090	0.100	0/2	10.3	6.60	13.9	0/2
GW-4006	175	170	180	0/2	<0.035	ND	0.030	1/2	8.75	7.70	9.80	0/2
GW-4007	208	205	210	0/2	0.215	0.100	0.330	0/2	9.40	8.80	10.0	0/2
GW-4008	220	220	---	0/2	0.054	0.048	0.060	0/2	8.45	8.40	8.50	0/2
GW-4009	250	250	---	0/2	0.069	0.058	0.080	0/2	9.25	7.70	10.8	0/2
GW-4010	305	300	310	0/2	0.072	0.070	0.074	0/2	10.5	10.0	10.9	0/2
GW-4011	275	270	280	0/2	0.250	0.180	0.320	0/2	9.75	7.90	11.6	0/2
GW-4012	368	305	430	0/2	0.085	0.060	0.110	0/2	9.75	7.10	12.4	0/2

TABLE A-2 Alkalinity, Phosphorous, and Silica Concentrations for Groundwater, 1993 (Continued)

	Alkalinity mg/l				Phosphorous mg/l				Silica, Dissolved mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-4013	315	310	320	0/2	0.145	0.120	0.170	0/2	11.1	10.9	11.3	0/2
GW-4014	285	285	--	0/1	0.155	0.090	0.220	0/2	9.80	9.40	10.2	0/2
GW-4015	245	240	250	0/2	0.095	0.050	0.140	0/2	7.50	4.00	11.0	0/2
GW-4016	230	220	240	0/2	0.125	0.080	0.170	0/2	9.50	9.00	10.0	0/2
GW-4017	330	330	--	0/1	0.115	0.100	0.130	0/2	10.9	10.5	11.2	0/2
GW-4018	425	400	450	0/2	0.071	0.031	0.110	0/2	8.95	8.80	9.10	0/2
GW-4019	280	280	--	0/2	<0.035	ND	0.044	1/2	9.05	7.70	10.4	0/2
GW-4020	395	390	400	0/2	0.100	0.060	0.140	0/2	6.85	4.90	8.80	0/2
GW-4021	530*	530	--	0/1	<0.050*	ND	ND	1/1	10.9*	10.9	--	0/1
GW-4022	288	270	300	0/4	0.265	0.120	0.520	0/4	9.95	7.90	12.7	0/4
GW-4023	405	400	410	0/2	<0.035	ND	0.034	1/2	11.6	8.60	14.6	0/2
GW-FINW	99.5	99.0	100	0/2								
GW-PW02	223	160	330	0/4	0.333	0.290	0.380	0/3	12.1	7.40	17.8	0/3
GW-PW03	172	150	194	0/2								
GW-PW04	165	165	--	0/1								
GW-PW05	254	210	298	0/2								
GW-PW06	160	160	--	0/1								
GW-PW07	310	310	--	0/1								
GW-PW08	340	340	--	0/1								

TABLE A-2 Alkalinity, Phosphorous, and Silica Concentrations for Groundwater, 1993 (Continued)

	Alkalinity mg/l				Phosphorous mg/l				Silica, Dissolved mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-PW03	336	328	350	0/4	0.340	0.300	0.400	0/3	18.7*	8.30	29.1	0/2
GW-RAWW	246	230	262	0/2								
GW-RMW1	335	230	440	0/2	0.290	0.170	0.410	0/2	22.4	20.2	24.6	0/2
GW-RMW2	390	380	400	0/2	0.280	0.250	0.310	0/2	16.9	10.8	23.0	0/2
GW-RMW3	495	480	510	0/2								
GW-RMW4	370	350	390	0/2								

TABLE A-3 Geochemical Concentrations for Groundwater, 1993

Location	Aluminum µg/l				Antimony µg/l				Arsenic µg/l				Barium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1002	<41.0	ND	47.6	2/4	<35.7	ND	ND	3/3	<3.33	ND	ND	6/6	124	ND	146	1/6
GW-1004									<4.67	ND	ND	3/3	<70.0	ND	38.0	1/3
GW-1005	67.0	ND	154	1/4	<35.7	ND	ND	3/3	<3.33	ND	ND	6/6	69.9	ND	69.7	1/6
GW-1006									<2.00	ND	ND	2/2	81.5	81.5	---	0/2
GW-1007									8.00	ND	15.0	1/2	298	232	363	0/2
GW-1008									<2.00	ND	ND	2/2	143	41.6	244	0/2
GW-1009									2.57	2.00	3.60	0/3	315	288	335	0/3
GW-1010									108	102	112	0/3	512	452	545	0/3
GW-1011									<2.00	ND	4.00	2/3	120	81.0	170	0/3
GW-1012									<2.00	ND	ND	4/4	169	126	286	0/4
GW-1013	<45.5	ND	ND	2/2	<47.0	ND	ND	1/1	2.48	2.10	2.90	0/4	161	147	190	0/4
GW-1014	<50.0	ND	ND	3/3	<43.5	ND	ND	2/2	<2.00	ND	2.80	3/5	174	121	335	0/5
GW-1015									<2.00	ND	ND	3/3	79.5	75.0	82.4	0/3
GW-1016									<2.00	ND	ND	3/3	109	94.2	132	0/3
GW-1017									171	161	180	0/2	1030	979	1080	0/2
GW-1018	<45.7	ND	ND	3/3	<30.0	ND	ND	2/2	76.4	45.2	103	0/3	576	389	672	0/3
GW-1019	<57.0	ND	ND	3/3	<43.0	ND	ND	2/2	65.5	48.9	79.6	0/3	769	671	847	0/3
GW-1020									32.9	24.5	41.3	0/2	434	430	438	0/2
GW-1021	<61.5	ND	ND	2/2	<40.0	ND	ND	1/1	79.0	76.5	81.5	0/2	742	721	762	0/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Aluminum µg/l				Antimony µg/l				Arsenic µg/l				Barium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1022	<45.7	ND	ND	3/3	<30.0	ND	ND	2/2	104	14.2	171	0/3	435	259	610	0/3
GW-1023									70.7	66.8	74.6	0/2	338	338	—	0/2
GW-1024									4.35	2.80	5.90	0/2	458	410	506	0/2
GW-1026									23.0	20.2	24.3	0/4	411	400	420	0/4
GW-1027									<2.00	ND	ND	3/3	90.5	81.6	101	0/3
GW-1028	<61.5	ND	ND	2/2	<40.0	ND	ND	1/1	<2.00	ND	2.20	1/3	255	242	282	0/3
GW-1029									<2.00	ND	ND	3/3	118	110	134	0/3
GW-1030									<2.00	ND	ND	3/3	133	110	169	0/3
GW-1031									<2.00	ND	ND	4/4	106	103	110	0/4
GW-1032	<61.5	ND	ND	2/2	<40.0	ND	ND	1/1	<2.00	ND	ND	3/3	91.6	88.6	94.8	0/3
GW-1033	<61.5	ND	ND	2/2	<40.0	ND	ND	1/1	<2.00	ND	2.90	1/2	456	423	488	0/2
GW-1034	<49.5	ND	35.9	3/4	<44.3	ND	ND	3/3	<2.00	ND	ND	4/4	144	139	156	0/4
GW-1035									<2.00	ND	ND	1/1	193	193	—	0/1
GW-1036									<2.00	ND	ND	1/1	249	249	—	0/1
GW-1037									2.79	2.79	—	0/1	686	686	—	0/1
GW-1038									<2.00	ND	ND	1/1	282	282	—	0/1
GW-1039									<2.00	ND	ND	1/1	458	458	—	0/1
GW-2001	<45.5	ND	ND	2/2	<52.0	ND	ND	2/2	<2.00	ND	ND	2/2	241	240	242	0/2
GW-2002	60.3	ND	88.6	1/2	<52.0	ND	ND	2/2	<2.00	ND	ND	2/2	169	143	194	0/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Aluminum µg/l				Antimony µg/l				Arsenic µg/l				Barium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2003	61.3	ND	90.6	1/2	<52.0	ND	ND	2/2	<2.00	ND	ND	2/2	186	183	188	0/2
GW-2004	42.2	ND	80.4	2/4	<41.0	ND	ND	4/4	<2.00	ND	ND	4/4	171	164	180	0/4
GW-2005	52.6	10.2	110	0/4	<30.8	ND	5.40	3/4	<2.000	ND	0.800	3/4	167	152	180	0/4
GW-2006	<42.4	ND	31.3	4/5	<42.0	ND	ND	5/5	<2.00	ND	ND	5/5	282	260	295	0/5
GW-2007	<87.5	ND	64.4	3/4	<61.0	ND	ND	4/4	<4.00	ND	ND	4/4	139	ND	165	1/4
GW-2008	<49.5	ND	ND	4/4	<47.5	ND	ND	4/4	<2.00	ND	2.20	3/4	299	278	319	0/4
GW-2009	<87.5	ND	86.3	3/4	<61.0	ND	ND	4/4	<4.00	ND	ND	4/4	265	254	275	0/4
GW-2010	<27.8	ND	ND	4/4	<30.8	ND	ND	4/4	<2.00	ND	1.80	3/4	257	243	268	0/4
GW-2011	<49.5	ND	71.0	3/4	<47.5	ND	ND	4/4	<2.00	ND	ND	4/4	140	133	144	0/4
GW-2012	<49.5	ND	92.2	3/4	<47.5	ND	ND	4/4	<2.00	ND	ND	4/4	118	111	121	0/4
GW-2013	<49.5	ND	86.3	2/4	<47.5	ND	ND	4/4	<2.00	ND	ND	4/4	206	198	213	0/4
GW-2014	<41.0	ND	26.3	3/4	<41.0	ND	ND	4/4	<2.00	ND	ND	4/4	239	216	251	0/4
GW-2015	<49.5	ND	ND	4/4	<47.5	ND	ND	4/4	<2.00	ND	ND	4/4	71.5	68.5	74.6	0/4
GW-2017	<41.0	ND	17.4	3/4	<41.0	ND	ND	4/4	<2.00	ND	ND	4/4	34.7	30.7	36.7	0/4
GW-2018	<41.0	ND	16.6	3/4	<41.0	ND	53.3	3/4	<2.00	ND	ND	4/4	433	417	448	0/4
GW-2019	<41.0	ND	ND	4/4	<41.0	ND	ND	4/4	<2.00	ND	3.60	3/4	142	121	176	0/4
GW-2020	<50.0	ND	34.1	2/3	<48.0	ND	ND	3/3	<2.00	ND	ND	3/3	42.3	37.7	49.0	0/3
GW-2021	<41.0	ND	ND	4/4	<41.0	ND	ND	4/4	<2.00	ND	ND	4/4	236	209	282	0/4
GW-2022	<36.3	ND	42.9	2/4	<37.3	ND	27.0	3/4	<2.00	ND	2.40	2/4	194	183	204	0/4

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Aluminum µg/l				Antimony µg/l				Arsenic µg/l				Barium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2023	<41.0	ND	ND	4/4	<41.0	ND	ND	4/4	<2.00	ND	ND	4/4	92.7	89.5	98.4	0/4
GW-2024	<41.0	ND	56.0	3/4	<41.0	ND	ND	4/4	<2.00	ND	2.50	3/4	83.7	78.5	87.0	0/4
GW-2025	<49.5	ND	ND	4/4	<47.5	ND	ND	4/4	<2.00	ND	ND	4/4	168	164	177	0/4
GW-2026	<37.8*	ND	ND	4/4	<34.3*	ND	ND	4/4	<2.00*	ND	ND	4/4	213*	196	229	0/4
GW-2027	<41.0	ND	ND	4/4	<41.0	ND	ND	4/4	<2.00	ND	ND	4/4	259	243	278	0/4
GW-2028	<49.5	ND	ND	4/4	<47.5	ND	ND	4/4	<2.00	ND	ND	4/4	129	114	138	0/4
GW-2029	42.0	ND	62.2	2/4	<41.0	ND	ND	4/4	<2.00	ND	ND	4/4	126	122	137	0/4
GW-2030	<41.0	ND	37.3	3/4	<41.0	ND	ND	4/4	<2.00	ND	ND	4/4	172	128	225	0/4
GW-2032	<46.3	ND	ND	4/4	<40.8	ND	ND	4/4	<2.00	ND	ND	4/4	311	270	346	0/4
GW-2033	<41.0	ND	18.4	3/4	<41.0	ND	ND	4/4	<2.00	ND	2.00	3/4	122	107	149	0/4
GW-2034	<49.5	ND	ND	4/4	<47.5	ND	ND	4/4	<2.00	ND	ND	4/4	14.4	12.8	15.7	0/4
GW-2035	<37.5	ND	ND	2/2	<46.5	ND	ND	2/2	<2.00	ND	ND	4/4	95.1	92.7	97.9	0/4
GW-2036	44.8	ND	65.6	1/2	<33.0	ND	ND	2/2	<2.00	ND	ND	4/4	255	238	272	0/4
GW-2037	<37.5	ND	ND	2/2	<46.5	ND	ND	2/2	<2.00	ND	ND	4/4	93.8	87.3	108	0/4
GW-2038	<37.5	ND	ND	2/2	<46.5	ND	ND	2/2	<2.00	ND	ND	4/4	313	261	388	0/4
GW-2039	<37.5	ND	36.1	1/2	<46.5	ND	51.9	1/2	<2.00	ND	2.00	3/4	189	166	220	0/4
GW-2040	<46.3	ND	ND	3/3	<50.0	ND	ND	3/3	<2.00	ND	ND	4/4	806	717	864	0/4
GW-2041	<37.5	ND	ND	2/2	<46.5	ND	ND	2/2	<2.00	ND	ND	4/4	227	183	315	0/4
GW-2042	<37.5	ND	ND	2/2	<46.5	ND	ND	2/2	<2.00	ND	ND	4/4	534	502	560	0/4

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Aluminum µg/l				Antimony µg/l				Arsenic µg/l				Barium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2043	<46.3	ND	ND	3/3	<50.0	ND	ND	3/3	<2.00	ND	ND	4/4	291	266	307	0/4
GW-3003	<45.5	ND	ND	2/2	<52.0	ND	ND	2/2	<2.00	ND	ND	2/2	154	147	161	0/2
GW-3006	<43.0	ND	ND	2/2	<43.5	ND	ND	2/2	2.20	2.00	2.39	0/2	136	130	142	0/2
GW-3008	56.4	ND	83.2	1/2	<43.5	ND	ND	2/2	<2.00	ND	ND	2/2	183	177	189	0/2
GW-3009	<45.5	ND	35.5	1/2	<52.0	ND	ND	2/2	<2.00	ND	ND	2/2	1110	1050	1170	0/2
GW-3019	<41.0	ND	34.5	2/4	<41.0	ND	ND	4/4	<2.00	ND	2.00	3/4	331	313	356	0/4
GW-3023	<41.0	ND	14.8	3/4	<41.0	ND	ND	4/4	<2.00	ND	ND	4/4	44.7	41.3	49.6	0/4
GW-4001	<39.0*	ND	16.2	1/2	<38.5*	ND	22.0	1/2	<2.00*	ND	ND	2/2	78.3*	77.6	78.9	0/2
GW-4002	<45.5	ND	ND	2/2	<52.0	ND	ND	2/2	<2.00	ND	ND	2/2	129	124	134	0/2
GW-4003	<43.0	ND	ND	2/2	<43.5	ND	ND	2/2	<2.00	ND	ND	2/2	178	174	182	0/2
GW-4004	<43.0	ND	ND	2/2	<43.5	ND	ND	2/2	<2.00	ND	ND	2/2	93.1	65.1	121	0/2
GW-4005	<45.5	ND	ND	2/2	<52.0	ND	ND	2/2	<2.00	ND	ND	2/2	99.9	91.8	108	0/2
GW-4006	<39.0*	ND	36.1	1/2	<38.5*	ND	20.0	1/2	<2.00*	ND	ND	2/2	173*	162	184	0/2
GW-4007	<43.0	ND	42.8	1/2	<43.5	ND	ND	2/2	<2.00	ND	ND	2/2	91.0	87.8	94.2	0/2
GW-4008	<43.0	ND	ND	2/2	<43.5	ND	ND	2/2	<2.00	ND	2.90	1/2	106	104	108	0/2
GW-4009	<43.0	ND	ND	2/2	<43.5	ND	ND	2/2	<2.00	ND	ND	2/2	110	108	111	0/2
GW-4010	<43.0	ND	ND	2/2	<43.5	ND	ND	2/2	<2.00	ND	ND	2/2	83.5	81.5	85.5	0/2
GW-4011	<43.0	ND	ND	2/2	<43.5	ND	ND	2/2	<2.00	ND	2.30	1/2	160	140	180	0/2
GW-4012	<45.5	ND	ND	2/2	<52.0	ND	ND	2/2	<2.00	ND	ND	2/2	56.9	24.3	89.5	0/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Aluminum µg/l				Antimony µg/l				Arsenic µg/l				Barium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-4013	69.8	ND	87.5	1/2	<52.0	ND	ND	2/2	<2.00	ND	ND	2/2	136	135	138	0/2
GW-4014	<45.5	ND	27.1	1/2	<52.0	ND	ND	2/2	<2.00	ND	ND	2/2	111	108	113	0/2
GW-4015	<43.0	ND	50.3	1/2	<43.5	ND	ND	2/2	<2.00	ND	ND	2/2	232	211	252	0/2
GW-4016	63.1	49.9	76.2	0/2	<43.5	ND	ND	2/2	<2.00	ND	ND	2/2	250	221	278	0/2
GW-4017	167	ND	305	1/2	<43.5	ND	ND	2/2	<2.00	ND	ND	2/2	163	137	189	0/2
GW-4018	<43.0	ND	ND	2/2	<43.5	ND	ND	2/2	<2.00	ND	ND	2/2	222	221	222	0/2
GW-4019	<43.0	ND	ND	2/2	<43.5	ND	ND	2/2	<2.00	ND	ND	2/2	202	190	213	0/2
GW-4020	47.5	ND	63.0	1/2	<52.0	ND	ND	2/2	<2.00	ND	ND	2/2	86.9	80.9	92.8	0/2
GW-4021	<27.0*	ND	ND	1/1	<47.0*	ND	ND	1/1	<2.00*	ND	ND	1/1	36.2*	36.2	--	0/1
GW-4022	615	ND	1870	1/4	<47.5	ND	ND	4/4	<2.00	ND	ND	4/4	92.2	80.0	113	0/4
GW-4023	<43.0	ND	ND	2/2	<43.5	ND	ND	2/2	<2.00	ND	2.30	1/2	89.2	89.0	89.4	0/2
GW-FINW									<2.00	ND	ND	3/3	94.1	83.0	109	0/4
GW-PW02	<55.3	ND	ND	3/3	<42.0	ND	ND	3/3	<2.00	ND	ND	4/4	326	301	370	0/4
GW-PW03									<2.00	ND	ND	4/4	277	234	299	0/4
GW-PW04									<2.00	ND	ND	2/2	265	257	272	0/2
GW-PW05									<2.00	ND	ND	4/4	419	364	512	0/4
GW-PW06									<2.00	ND	ND	2/2	313	301	324	0/2
GW-PW07									<2.00	ND	ND	2/2	507	497	517	0/2
GW-PW08									3.40	3.10	3.70	0/2	454	445	462	0/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Aluminum µg/l				Antimony µg/l				Arsenic µg/l				Barium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-PW09	<57.0	ND	ND	3/3	<47.7	ND	ND	3/3	3.78	2.80	4.40	0/4	478	423	509	0/4
GW-RAWW									<2.00	ND	ND	4/4	364	346	392	0/3
GW-RMW1	<59.0	ND	ND	2/2	<40.0	ND	ND	2/2	5.40	4.40	6.40	0/2	513	512	513	0/2
GW-RMW2	<59.0	ND	ND	2/2	<40.0	ND	ND	2/2	24.5	18.0	31.0	0/2	271	266	275	0/2
GW-RMW3									28.4	26.3	30.5	0/2	675	615	734	0/2
GW-RMW4									10.5	5.30	15.0	0/2	175	160	190	0/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Beryllium µg/l				Cadmium µg/l				Calcium µg/l				Chromium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1002	<1.000	ND	ND	3/3	<4.00	ND	5.40	2/3	109075	96300	116000	0/4	<5.25	ND	ND	4/4
GW-1004																
GW-1005	1.10	ND	1.60	1/3	<4.00	ND	ND	3/3	95525	89400	100000	0/4	<5.25	ND	ND	4/4
GW-1006																
GW-1007																
GW-1008																
GW-1009																
GW-1010																
GW-1011																
GW-1012																
GW-1013	<1.000	ND	ND	1/1	<5.00	ND	ND	1/1	141000	134000	148000	0/2	<6.00	ND	ND	2/2
GW-1014	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	122400	74200	158000	0/3	<6.00	ND	ND	3/3
GW-1015																
GW-1016																
GW-1017																
GW-1018	<1.000	ND	ND	2/2	<3.50	ND	ND	2/2	135667	120000	146000	0/3	<5.33	ND	ND	3/3
GW-1019	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	119667	115000	126000	0/3	<6.33	ND	ND	3/3
GW-1020																
GW-1021	<1.000	ND	ND	1/1	<5.00	ND	ND	1/1	118000	111000	125000	0/2	<6.50	ND	ND	2/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Beryllium µg/l				Cadmium µg/l				Calcium µg/l				Chromium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1022	<1.000	ND	ND	2/2	<3.50	ND	ND	2/2	111367	97100	135000	0/3	<5.33	ND	ND	3/3
GW-1023																
GW-1024																
GW-1026																
GW-1027																
GW-1028	<1.000	ND	ND	1/1	<5.00	ND	ND	1/1	137000	133000	141000	0/2	<6.50	ND	ND	2/2
GW-1029																
GW-1030																
GW-1031																
GW-1032	<1.000	ND	ND	1/1	<5.00	ND	ND	1/1	151500	151000	152000	0/2	<6.50	ND	ND	2/2
GW-1033	<1.000	ND	ND	1/1	<5.00	ND	ND	1/1	70100	66500	73700	0/2	<6.50	ND	ND	2/2
GW-1034	<1.000	ND	1.70	2/3	<5.00	ND	ND	3/3	172500	162000	191000	0/4	<6.00	ND	ND	4/4
GW-1035					<4.00	ND	ND	1/1					<7.00	ND	ND	1/1
GW-1036									154000	154000	—	0/1	<7.00	ND	ND	1/1
GW-1037					<4.00	ND	ND	1/1					<7.00	ND	ND	1/1
GW-1038					<4.00	ND	ND	1/1					<7.00	ND	ND	1/1
GW-1039					<4.00	ND	ND	1/1					<7.00	ND	ND	1/1
GW-2001	<1.000	ND	ND	2/2	<4.50	ND	ND	2/2	97050	95300	98800	0/2	<6.00	ND	ND	2/2
GW-2002	<1.000	ND	ND	2/2	<4.50	ND	ND	2/2	262500	236000	289000	0/2	<6.00	ND	ND	2/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Beryllium µg/l				Cadmium µg/l				Calcium µg/l				Chromium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2003	<1.000	ND	ND	2/2	<4.50	ND	ND	2/2	294500	291000	298000	0/2	<6.00	ND	ND	2/2
GW-2004	<1.000	ND	ND	4/4	<4.00	ND	ND	4/4	69400	63000	74400	0/4	<5.25	ND	ND	4/4
GW-2005	<1.000	ND	1.40	2/4	<3.50	ND	0.700	3/4	100100	91200	110000	0/4	<4.00	ND	ND	4/4
GW-2006	<1.000	ND	ND	5/5	<4.20	ND	ND	5/5	125200	116000	132000	0/5	<5.40	ND	ND	5/5
GW-2007	<2.00	ND	ND	4/4	<4.75	ND	ND	4/4	57350	54600	59300	0/4	10.8	6.80	15.2	0/4
GW-2008	<1.000	ND	ND	4/4	<4.75	ND	ND	4/4	122000	114000	130000	0/4	<5.00	ND	ND	4/4
GW-2009	<2.00	ND	ND	4/4	<4.75	ND	ND	4/4	161500	156000	167000	0/4	<7.00	ND	ND	4/4
GW-2010	<1.000	ND	1.40	3/4	<3.50	ND	ND	4/4	108250	102000	114000	0/4	<4.00	ND	ND	4/4
GW-2011	<1.000	ND	ND	4/4	<4.67*	ND	ND	3/3	61875	56800	65900	0/4	<6.00	ND	7.60	3/4
GW-2012	<1.000	ND	ND	4/4	<4.75	ND	ND	4/4	127750	121000	132000	0/4	<6.00	ND	8.30	3/4
GW-2013	<1.000	ND	ND	4/4	<4.75	ND	ND	4/4	112250	105000	126000	0/4	<6.00	ND	7.70	3/4
GW-2014	<1.000	ND	ND	4/4	<4.00	ND	ND	4/4	131250	122000	142000	0/4	<5.25	ND	11.6	3/4
GW-2015	<1.000	ND	ND	4/4	<4.67*	ND	ND	3/3	77725	76900	78800	0/4	<6.00	ND	7.60	3/4
GW-2017	<1.000	ND	ND	4/4	<4.00	ND	ND	4/4	179000	162000	191000	0/4	<5.25	ND	ND	4/4
GW-2018	<1.000	ND	ND	4/4	<4.00	ND	ND	4/4	76975	73700	79000	0/4	<5.25	ND	7.40	3/4
GW-2019	<1.000	ND	ND	4/4	<4.00	ND	ND	4/4	24050	19000	30500	0/4	<5.25	ND	ND	4/4
GW-2020	<1.000	ND	ND	3/3	<4.67	ND	ND	3/3	101667	98800	107000	0/3	<5.00	ND	ND	3/3
GW-2021	<1.000	ND	ND	4/4	<4.00	ND	ND	4/4	62850	56900	77800	0/4	<5.25	ND	3.90	3/4
GW-2022	<1.000	ND	1.40	3/4	<4.00*	ND	ND	3/3	55350	53200	58100	0/4	<4.75	ND	12.0	3/4

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Beryllium µg/l				Cadmium µg/l				Calcium µg/l				Chromium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2023	<1.000	ND	ND	4/4	<4.00	ND	ND	4/4	41750	39300	45700	0/4	6.65	ND	17.6	3/4
GW-2024	<1.000	ND	1.80	3/4	<4.00	ND	ND	4/4	62300	58200	67700	0/4	<5.25	ND	7.80	3/4
GW-2025	<1.000	ND	ND	4/4	<4.75	ND	ND	4/4	55950	53900	58000	0/4	<6.00	ND	ND	4/4
GW-2026	<1.000*	ND	ND	4/4	<3.25*	ND	ND	4/4	65225*	58500	70500	0/4	<4.75*	ND	6.60	3/4
GW-2027	<1.000	ND	ND	4/4	<4.00	ND	ND	4/4	67300	64900	68800	0/4	<5.25	ND	11.1	3/4
GW-2028	<1.000	ND	ND	4/4	<4.75	ND	ND	4/4	76300	74200	78100	0/4	6.03	ND	15.1	3/4
GW-2029	<1.000	ND	ND	4/4	<4.67*	ND	ND	3/3	68950	61300	64100	0/4	<5.25	ND	3.20	3/4
GW-2030	<1.000	ND	1.20	3/4	<4.00	ND	ND	4/4	134250	124000	149000	0/4	<5.25	ND	6.10	3/4
GW-2032	<1.000	ND	ND	4/4	<4.00	ND	ND	4/4	164000	152000	180000	0/4	<5.50	ND	ND	4/4
GW-2033	<1.000	ND	ND	4/4	<4.00	ND	ND	4/4	117850	88400	129000	0/4	<5.25	ND	4.10	3/4
GW-2034	<1.000	ND	ND	4/4	<4.75	ND	5.00	3/4	139000	120000	169000	0/4	<6.00	ND	ND	4/4
GW-2035	<1.000	ND	ND	2/2	<5.00	ND	ND	3/3	36550	35600	37500	0/2	<5.67	ND	ND	3/3
GW-2036	<1.000	ND	ND	2/2	<4.00	ND	2.70	2/3	52250	49100	55400	0/2	<5.00	ND	ND	3/3
GW-2037	<1.000	ND	ND	2/2	<5.00	ND	ND	3/3	333000	329000	337000	0/2	<5.67	ND	ND	3/3
GW-2038	<1.000	ND	ND	2/2	<5.00	ND	ND	3/3	1037000	944000	1130000	0/2	<5.67	ND	ND	3/3
GW-2039	1.80	ND	3.10	1/2	<5.00	ND	5.70	2/3	86300	82200	90400	0/2	<5.67	ND	ND	3/3
GW-2040	<1.000	ND	ND	3/3	<4.67	ND	ND	3/3	162000	139000	180000	0/3	<6.00	ND	11.8	2/3
GW-2041	<1.000	ND	ND	2/2	<5.00	ND	ND	3/3	1018000	826000	1210000	0/2	<5.67	ND	7.20	2/3
GW-2042	<1.000	ND	1.30	1/2	<5.00	ND	ND	3/3	76250	74500	78000	0/2	<5.67	ND	ND	3/3

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Beryllium µg/l				Cadmium µg/l				Calcium µg/l				Chromium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2043	<1.000	ND	ND	3/3	<4.67	ND	ND	3/3	53367	51000	55300	0/3	<6.00	ND	ND	3/3
GW-3003	<1.000	ND	1.20	1/2	<4.50	ND	ND	2/2	224000	213000	235000	0/2	<6.00	ND	ND	2/2
GW-3006	<1.000	ND	1.20	1/2	<5.00	ND	ND	2/2	59550	59200	59900	0/2	<5.50	ND	ND	2/2
GW-3008	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	468500	445000	492000	0/2	<5.50	ND	ND	2/2
GW-3009	<1.000	ND	ND	2/2	<4.50	ND	ND	2/2	153000	140000	166000	0/2	<6.00	ND	ND	2/2
GW-3019	<1.000	ND	ND	4/4	<4.00	ND	ND	4/4	42725	40000	47600	0/4	<5.25	ND	10.1	3/4
GW-3023	<1.000	ND	1.20	3/4	<4.00	ND	ND	4/4	316500	285000	372000	0/4	<5.25	ND	ND	4/4
GW-4001	<1.000*	ND	ND	2/2	<3.00*	ND	ND	2/2	85200*	84900	85500	0/2	<5.00*	ND	ND	2/2
GW-4002	<1.000	ND	ND	2/2	4.75	ND	7.50	1/2	51200	49300	53100	0/2	<6.00	ND	ND	2/2
GW-4003	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	59400	56200	62600	0/2	<5.50	ND	ND	2/2
GW-4004	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	31700	31000	32400	0/2	<5.50	ND	ND	2/2
GW-4005	1.40	ND	2.30	1/2	<4.50	ND	ND	2/2	47300	44200	50400	0/2	7.55	6.90	8.20	0/2
GW-4006	<1.000*	ND	ND	2/2	<3.00*	ND	ND	2/2	49100*	47300	50900	0/2	<5.00*	ND	ND	2/2
GW-4007	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	32650	31800	33500	0/2	<5.50	ND	ND	2/2
GW-4008	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	37150	36700	37600	0/2	<5.50	ND	ND	2/2
GW-4009	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	36250	34900	37600	0/2	16.7	ND	30.8	1/2
GW-4010	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	53950	53400	54500	0/2	<5.50	ND	ND	2/2
GW-4011	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	77750	74100	81400	0/2	<5.50	ND	ND	2/2
GW-4012	<1.000	ND	ND	2/2	<4.50	ND	ND	2/2	30750	15700	45800	0/2	74.4	9.70	139	0/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Beryllium μg/l				Cadmium μg/l				Calcium μg/l				Chromium μg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-4013	<1.000	ND	ND	2/2	<4.50	ND	ND	2/2	125500	123000	128000	0/2	<6.00	ND	ND	2/2
GW-4014	<1.000	ND	ND	2/2	<4.50	ND	ND	2/2	62050	61700	62400	0/2	<6.00	ND	ND	2/2
GW-4015	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	56500	55200	57800	0/2	<5.50	ND	ND	2/2
GW-4016	1.30	ND	2.10	1/2	<5.00	ND	ND	2/2	43500	41100	45900	0/2	<5.50	ND	5.90	1/2
GW-4017	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	58250	53600	62900	0/2	<5.50	ND	6.70	1/2
GW-4018	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	101000	100000	102000	0/2	<5.50	ND	ND	2/2
GW-4019	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	38100	36800	39400	0/2	<5.50	ND	ND	2/2
GW-4020	<1.000	ND	ND	2/2	<4.50	ND	ND	2/2	100800	97600	104000	0/2	<6.00	ND	ND	2/2
GW-4021	<1.000	ND	ND	1/1	<5.00	ND	ND	1/1	123000	123000	---	0/1	<5.00	ND	ND	1/1
GW-4022	<1.000	ND	ND	4/4	<4.75	ND	ND	4/4	45375	43200	49100	0/4	8.83	ND	22.8	2/4
GW-4023	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	95000	92400	97600	0/2	<5.50	ND	ND	2/2
GW-FINW					<4.00	ND	ND	1/1								
GW-PW02	<1.000	ND	ND	3/3	<5.00	ND	ND	3/3	57233	54500	62400	0/3	<6.00	ND	ND	3/3
GW-PW03					<5.00	ND	ND	1/1					<6.00	ND	ND	1/1
GW-PW04					4.50	4.50	---	0/1								
GW-PW05					<5.00	ND	ND	1/1					<6.00	ND	ND	1/1
GW-PW06					<5.00	ND	ND	1/1					<6.00	ND	ND	1/1
GW-PW07					<4.00	ND	ND	1/1								
GW-PW08					<4.00	ND	ND	1/1								

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Beryllium µg/l				Cadmium µg/l				Calcium µg/l				Chromium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-PW09	1.07	ND	2.20	2/3	<4.67	ND	ND	3/3	108333	103000	114000	0/3	<6.33	ND	ND	3/3
GW-RAWW					<4.00	ND	ND	1/1								
GW-RMW1	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	128500	123000	134000	0/2	<6.00	ND	8.40	1/2
GW-RMW2	<1.000	ND	ND	2/2	<5.00	ND	ND	2/2	121500	121000	122000	0/2	<6.00	ND	ND	2/2
GW-RMW3																
GW-RMW4																

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Cobalt µg/l				Copper µg/l				Iron µg/l				Lead µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1002	<6.33	ND	ND	3/3	<6.33	ND	ND	3/3	22.5	ND	74.8	3/4	<2.00	ND	2.89	2/4
GW-1004																
GW-1005	<6.33	ND	ND	3/3	<6.33	ND	ND	3/3	21.7	ND	54.2	2/4	<6.50	ND	3.30	3/4
GW-1006																
GW-1007																
GW-1008																
GW-1009																
GW-1010																
GW-1011																
GW-1012																
GW-1013	<8.00	ND	ND	1/1	<6.00	ND	ND	1/1	3045	2950	3140	0/2	<2.00	ND	ND	2/2
GW-1014	<7.00	ND	ND	2/2	<6.00	ND	ND	2/2	2610	1580	3680	0/3	2.43	ND	5.30	2/3
GW-1015																
GW-1016																
GW-1017																
GW-1018	<5.50	ND	ND	2/2	<6.50	ND	ND	2/2	25567	12300	32600	0/3	2.83	ND	6.50	2/3
GW-1019	<6.50	ND	ND	2/2	<8.50	ND	ND	2/2	10453	4960	13400	0/3	<2.00	ND	ND	3/3
GW-1020																
GW-1021	<6.00	ND	ND	1/1	<10.00	ND	ND	1/1	12850	11500	14200	0/2	<2.00	ND	ND	2/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Cobalt µg/l				Copper µg/l				Iron µg/l				Lead µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1022	<6.50	ND	ND	2/2	<6.50	ND	ND	2/2	17144	532	29300	0/3	<2.00	ND	ND	3/3
GW-1023																
GW-1024																
GW-1026																
GW-1027																
GW-1028	<6.00	ND	ND	1/1	<10.00	ND	ND	1/1	92.2	86.7	97.6	0/2	<2.00	ND	ND	2/2
GW-1029																
GW-1030																
GW-1031																
GW-1032	<6.00	ND	ND	1/1	<10.00	ND	ND	1/1	8.65	ND	13.8	1/2	<2.00	ND	ND	2/2
GW-1033	<6.00	ND	ND	1/1	<10.00	ND	ND	1/1	172	128	215	0/2	37.5	ND	73.9	1/2
GW-1034	<7.00	ND	ND	3/3	<7.67	ND	ND	3/3	23.0	17.0	29.9	0/4	12.3	ND	44.7	2/4
GW-1035													<2.00	ND	ND	1/1
GW-1036													<2.00	ND	ND	1/1
GW-1037													<2.00	ND	ND	1/1
GW-1038													<2.00	ND	ND	1/1
GW-1039													<2.00	ND	ND	1/1
GW-2001	<8.00	ND	ND	2/2	<7.50	ND	ND	2/2	23.6	ND	40.7	1/2	<2.00	ND	ND	2/2
GW-2002	<8.00	ND	ND	2/2	<7.50	ND	ND	2/2	<11.50	ND	ND	2/2	2.25	ND	3.50	1/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Cobalt µg/l				Copper µg/l				Iron µg/l				Lead µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2003	<8.00	ND	ND	2/2	<7.50	ND	ND	2/2	<11.50	ND	11.6	1/2	<2.00	ND	ND	2/2
GW-2004	<6.75	ND	6.10	3/4	<7.00	ND	ND	4/4	15.0	ND	26.3	1/4	<2.00	ND	ND	4/4
GW-2005	<5.25	ND	ND	4/4	<5.00	ND	ND	4/4	<68.8	ND	53.7	1/4	<1.75	ND	3.10	3/4
GW-2006	<6.80	ND	ND	5/5	<7.00	ND	ND	5/5	29.3	19.2	45.8	0/5	<2.00	ND	2.60	4/5
GW-2007	<18.00	ND	ND	4/4	<12.50	ND	ND	4/4	<32.5	ND	16.6	2/4	7.25	ND	24.4	2/4
GW-2008	<7.25	ND	ND	4/4	<8.00	ND	ND	4/4	29.0	22.1	37.1	0/4	<2.00	ND	4.30	3/4
GW-2009	<18.00	ND	ND	4/4	<12.50	ND	ND	4/4	<32.5	ND	15.4	2/4	2.43	ND	6.20	3/4
GW-2010	<5.25	ND	ND	4/4	<5.00	ND	0.400	3/4	<68.8	ND	30.6	1/4	<1.75	ND	2.50	3/4
GW-2011	<7.25	ND	ND	4/4	<8.00	ND	ND	4/4	19.9	ND	36.6	1/4	<2.00	ND	ND	4/4
GW-2012	<7.25	ND	ND	4/4	<8.00	ND	ND	4/4	23.4	ND	38.6	1/4	3.10	ND	7.20	2/4
GW-2013	<7.25	ND	ND	4/4	<8.00	ND	ND	4/4	13.6	11.3	16.8	0/4	<2.00	ND	2.40	2/4
GW-2014	<6.75	ND	ND	4/4	<7.00	ND	ND	4/4	16.9	ND	52.7	3/4	3.60	ND	8.10	2/4
GW-2015	<7.25	ND	ND	4/4	<8.00	ND	ND	4/4	78.3	ND	255	1/4	4.83	2.90	7.50	0/4
GW-2017	<6.75	ND	ND	4/4	<7.00	ND	ND	4/4	16.4	ND	32.3	1/4	<11.00	ND	21.0	2/4
GW-2018	<6.75	ND	8.40	3/4	<7.00	ND	ND	4/4	18.5	ND	25.6	1/4	<2.00	ND	2.30	3/4
GW-2019	<6.75	ND	ND	4/4	<7.00	ND	ND	4/4	14.4	ND	26.7	2/4	5.65	ND	16.3	2/4
GW-2020	<7.33	ND	10.6	2/3	<8.33	ND	ND	3/3	35.9	13.5	65.3	0/3	<2.00	ND	2.90	2/3
GW-2021	<6.75	ND	ND	4/4	<7.00	ND	ND	4/4	14.4	7.40	24.6	0/4	<2.00	ND	2.50	3/4
GW-2022	<5.75	ND	ND	4/4	<6.00	ND	0.800	3/4	<69.3	ND	67.7	1/4	<1.75	ND	2.90	2/4

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Cobalt µg/l				Copper µg/l				Iron µg/l				Lead µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2023	<6.75	ND	ND	4/4	<7.00	ND	ND	4/4	16.8	ND	45.1	2/4	<2.00	ND	2.20	3/4
GW-2024	<6.75	ND	ND	4/4	<7.00	ND	ND	4/4	65.8	34.1	91.6	0/4	<2.00	ND	3.80	3/4
GW-2025	<7.25	ND	ND	4/4	<8.00	ND	ND	4/4	40.3	ND	91.7	1/4	14.6	ND	36.6	2/4
GW-2026	<6.00*	ND	ND	4/4	<6.25*	ND	ND	4/4	8.28*	ND	22.1	3/4	<2.00*	ND	ND	4/4
GW-2027	<6.75	ND	ND	4/4	<7.00	ND	ND	4/4	81.1	19.3	233	0/4	<2.00	ND	3.70	3/4
GW-2028	<7.25	ND	ND	4/4	<8.00	ND	ND	4/4	185	33.3	572	0/4	2.30	ND	4.70	2/4
GW-2029	<6.75	ND	ND	4/4	<7.00	ND	ND	4/4	16.6	ND	37.8	1/4	2.55	ND	5.20	2/4
GW-2030	<6.75	ND	ND	4/4	<7.00	ND	7.20	3/4	42.6	ND	76.9	1/4	13.8	ND	47.7	2/4
GW-2032	<6.50	ND	ND	4/4	<7.25	ND	ND	4/4	26.1	12.0	37.0	0/4	<2.00	ND	4.80	3/4
GW-2033	<6.75	ND	ND	4/4	<7.00	ND	ND	4/4	30.5	ND	62.0	1/4	2.73	ND	4.90	2/4
GW-2034	<7.25	ND	8.80	1/4	<8.00	ND	6.80	3/4	127	ND	486	2/4	<6.50	ND	4.40	1/4
GW-2035	<7.50	ND	ND	2/2	<6.50	ND	ND	2/2	17.0	9.90	25.1	0/2	<2.00	ND	2.90	2/3
GW-2036	<6.00	ND	ND	2/2	<5.00	ND	ND	2/2	27.7	10.4	45.0	0/2	<2.00	ND	ND	3/3
GW-2037	13.6	13.5	13.7	0/2	<6.50	ND	ND	2/2	<10.00	ND	10.1	1/2	<2.00	ND	ND	3/3
GW-2038	<7.50	ND	ND	2/2	<6.50	ND	ND	2/2	<10.00	ND	11.0	1/2	<2.00	ND	ND	3/3
GW-2039	16.2	ND	28.9	1/2	9.00	ND	14.5	1/2	22.0	20.1	23.9	0/2	<2.00	ND	ND	3/3
GW-2040	<7.67	ND	ND	3/3	<7.33	ND	ND	3/3	29.4	ND	44.3	1/3	<2.00	ND	2.50	2/3
GW-2041	<7.50	ND	ND	2/2	<6.50	ND	ND	2/2	20.1	ND	33.7	1/2	2.93	ND	6.80	2/3
GW-2042	<7.50	ND	ND	2/2	<6.50	ND	ND	2/2	15.9	ND	25.2	1/2	<2.00	ND	ND	3/3

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Cobalt µg/l				Copper µg/l				Iron µg/l				Lead µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2043	<7.67	ND	ND	3/3	<7.33	ND	ND	3/3	47.2	ND	114	1/3	<2.00	ND	2.20	2/3
GW-3003	<8.00	ND	ND	2/2	<7.50	ND	ND	2/2	<11.50	ND	ND	2/2	<2.00	ND	2.10	1/2
GW-3006	<7.00	ND	ND	2/2	<8.00	ND	ND	2/2	70.8	ND	135	1/2	2.50	2.10	2.89	0/2
GW-3008	<7.00	ND	ND	2/2	<8.00	ND	6.00	1/2	12.7	ND	21.8	1/2	<2.00	ND	2.30	1/2
GW-3009	10.4	9.90	10.9	0/2	<7.50	ND	ND	2/2	12.4	ND	19.8	1/2	4.15	ND	7.30	1/2
GW-3019	<6.75	ND	ND	4/4	<7.00	ND	ND	4/4	77.9	ND	264	1/4	3.78	ND	11.1	2/4
GW-3023	<6.75	ND	ND	4/4	<7.00	ND	ND	4/4	24.0	ND	66.6	2/4	<2.00	ND	ND	4/4
GW-4001	<6.50*	ND	ND	2/2	<6.00*	ND	ND	2/2	7.90*	ND	13.3	1/2	<2.00*	ND	ND	2/2
GW-4002	<8.00	ND	ND	2/2	<7.50	ND	ND	2/2	59.7	19.4	100	0/2	<2.00	ND	ND	2/2
GW-4003	<7.00	ND	ND	2/2	<8.00	ND	ND	2/2	13.6	ND	23.6	1/2	2.10	ND	3.20	1/2
GW-4004	<7.00	ND	ND	2/2	<8.00	ND	ND	2/2	14.8	11.9	17.8	0/2	<2.00	ND	ND	2/2
GW-4005	<8.00	ND	ND	2/2	<7.50	ND	ND	2/2	<11.5	ND	14.9	1/2	2.50	2.40	2.60	0/2
GW-4006	<6.50*	ND	ND	2/2	<6.00*	ND	ND	2/2	11.9*	ND	21.2	1/2	<2.00*	ND	ND	2/2
GW-4007	<7.00	ND	ND	2/2	<8.00	ND	ND	2/2	13.8	ND	24.1	1/2	<2.00	ND	ND	2/2
GW-4008	<7.00	ND	ND	2/2	<8.00	ND	ND	2/2	11.9	ND	17.2	1/2	<2.00	ND	ND	2/2
GW-4009	<7.00	ND	ND	2/2	<8.00	ND	ND	2/2	10.6	ND	14.7	1/2	<2.00	ND	ND	2/2
GW-4010	<7.00	ND	ND	2/2	<8.00	ND	ND	2/2	27.6	21.1	34.1	0/2	11.7	10.1	13.2	0/2
GW-4011	<7.00	ND	ND	2/2	<8.00	ND	ND	2/2	25.6	15.6	35.6	0/2	<2.00	ND	ND	2/2
GW-4012	<8.00	ND	ND	2/2	<7.50	ND	ND	2/2	30.0	14.8	45.1	0/2	10.7	7.20	14.2	0/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Cobalt µg/l				Copper µg/l				Iron µg/l				Lead µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-4013	<8.00	ND	ND	2/2	<7.50	ND	ND	2/2	22.1	13.5	30.6	0/2	<2.00	ND	ND	2/2
GW-4014	<8.00	ND	ND	2/2	<7.50	ND	ND	2/2	47.5	42.3	52.7	0/2	<2.00	ND	ND	2/2
GW-4015	<7.00	ND	ND	2/2	<8.00	ND	ND	2/2	27.2	7.90	46.5	0/2	<2.00	ND	ND	2/2
GW-4016	14.5	ND	25.9	1/2	9.25	ND	13.5	1/2	18.5	ND	33.5	1/2	21.7	ND	42.4	1/2
GW-4017	<7.00	ND	ND	2/2	<8.00	ND	ND	2/2	343	89.9	597	0/2	9.85	ND	18.7	1/2
GW-4018	<7.00	ND	ND	2/2	<8.00	ND	ND	2/2	<10.00	ND	ND	2/2	2.50	2.50	—	0/2
GW-4019	<7.00	ND	ND	2/2	<8.00	ND	ND	2/2	21.5	9.90	33.1	0/2	2.80	ND	4.59	1/2
GW-4020	<8.00	ND	ND	2/2	<7.50	ND	ND	2/2	25.2	ND	43.9	1/2	<2.00	ND	2.00	1/2
GW-4021	<8.00*	ND	ND	1/1	<8.00*	ND	ND	1/1	<13.00*	ND	ND	1/1	<2.00*	ND	ND	1/1
GW-4022	<7.25	ND	ND	4/4	<8.00	ND	ND	4/4	961	31.8	3100	0/4	5.85	ND	17.1	2/4
GW-4023	<7.00	ND	ND	2/2	<8.00	ND	ND	2/2	<10.00	ND	11.8	1/2	2.40	ND	3.80	1/2
GW-FINW													<2.00	ND	ND	1/1
GW-PW02	<6.33	ND	ND	3/3	<9.00	ND	ND	3/3	3270	2980	3810	0/3	<8.33	ND	ND	3/3
GW-PW03													<2.00	ND	ND	1/1
GW-PW04													<2.00	ND	ND	1/1
GW-PW05													<2.00	ND	ND	1/1
GW-PW06													3.00	3.00	—	0/1
GW-PW07													<2.00	ND	ND	1/1
GW-PW08													2.50	2.50	—	0/1

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Cobalt µg/l				Copper µg/l				Iron µg/l				Lead µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-PW09	<7.00	ND	ND	3/3	<6.67	ND	ND	3/3	5507	4690	6110	0/3	<2.00	ND	2.20	2/3
GW-RAWW													<2.00	ND	ND	1/1
GW-RMW1	<6.00	ND	ND	2/2	<10.00	ND	ND	2/2	4880	3870	5890	0/2	<2.00	ND	2.20	1/2
GW-RMW2	<6.00	ND	ND	2/2	<10.00	ND	ND	2/2	4735	4710	4760	0/2	3.35	ND	5.70	1/2
GW-RMW3																
GW-RMW4																

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Lithium µg/l				Magnesium µg/l				Manganese µg/l				Mercury µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1002	<25.8	ND	23.3	3/4	21300	17300	23200	0/4	419	312	468	0/4	<0.100	ND	ND	3/3
GW-1004																
GW-1005	<25.8	ND	47.1	3/4	34075	31000	35700	0/4	508	412	609	0/4	<0.100	ND	ND	3/3
GW-1006																
GW-1007																
GW-1008																
GW-1009																
GW-1010																
GW-1011																
GW-1012																
GW-1013	<32.0	ND	ND	2/2	31200	30100	32300	0/2	530	528	531	0/2	<0.100	ND	ND	1/1
GW-1014	<28.0	ND	49.8	2/3	26833	17100	34000	0/3	469	416	514	0/3	<0.100	ND	ND	2/2
GW-1015																
GW-1016																
GW-1017																
GW-1018	<22.7	ND	20.5	2/3	37233	30900	41000	0/3	616	434	736	0/3	<0.100	ND	ND	2/2
GW-1019	<25.7	ND	35.4	2/3	34267	32900	35100	0/3	420	313	593	0/3	<0.100	ND	ND	2/2
GW-1020																
GW-1021	<24.5	ND	ND	2/2	36750	33800	39700	0/2	273	261	285	0/2	<0.100	ND	ND	1/1

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Lithium µg/l				Magnesium µg/l				Manganese µg/l				Mercury µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1022	<22.7	ND	ND	3/3	30633	23300	39900	0/3	339	285	374	0/3	<0.100	ND	ND	2/2
GW-1023																
GW-1024																
GW-1026																
GW-1027																
GW-1028	30.0	23.2	36.8	0/2	30300	30100	30500	0/2	286	242	330	0/2	<0.100	ND	ND	1/1
GW-1029																
GW-1030																
GW-1031																
GW-1032	<24.5	ND	35.0	1/2	44950	44400	45500	0/2	9.60	8.60	10.6	0/2	<0.100	ND	ND	1/1
GW-1033	<24.5	ND	ND	2/2	33100	32800	33400	0/2	272	244	300	0/2	<0.100	ND	ND	1/1
GW-1034	<28.0	ND	ND	4/4	26100	17600	33400	0/4	21.8	16.7	28.5	0/4	<0.100	ND	0.110	2/3
GW-1035					12300	12300	---	0/1					<0.200	ND	ND	1/1
GW-1036					33600	33600	---	0/1					<0.100	ND	ND	1/1
GW-1037					35500	35500	---	0/1					<0.100	ND	ND	1/1
GW-1038					35700	35700	---	0/1					<0.100	ND	ND	1/1
GW-1039					36700	36700	---	0/1					<0.100	ND	ND	1/1
GW-2001	<32.0	ND	ND	2/2	47500	46000	49000	0/2	<2.00	ND	2.00	1/2	<0.100	ND	ND	2/2
GW-2002	412	310	513	0/2	77050	55600	98500	0/2	<2.00	ND	2.50	1/2	<0.100	ND	ND	2/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Lithium μg/l				Magnesium μg/l				Manganese μg/l				Mercury μg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2003	544	497	590	0/2	114000	109000	119000	0/2	<2.00	ND	ND	2/2	<0.100	ND	0.110	1/2
GW-2004	<25.8	ND	ND	4/4	44675	40200	48300	0/4	<2.25	ND	3.10	3/4	<0.100	ND	ND	4/4
GW-2005	60.8	ND	93.2	1/4	50850	47600	55300	0/4	<2.00	ND	1.00	3/4	<0.100	ND	ND	4/4
GW-2006	<26.2	ND	ND	5/5	56520	52100	59400	0/5	24.3	14.7	33.6	0/5	<0.100	ND	ND	5/5
GW-2007	<46.0	ND	ND	4/4	43625	42800	44500	0/4	11.4	ND	23.2	1/4	<0.125	ND	ND	4/4
GW-2008	<28.0	ND	ND	4/4	44750	42400	47400	0/4	27.3	23.3	36.6	0/4	<0.100	ND	ND	4/4
GW-2009	<46.0	ND	ND	4/4	14525	13800	15300	0/4	<5.50	ND	ND	4/4	<0.125	ND	ND	4/4
GW-2010	<21.0	ND	23.1	3/4	22475	19700	24100	0/4	20.5	13.0	36.7	0/4	<0.100	ND	0.080	3/4
GW-2011	<28.0	ND	ND	4/4	32725	29700	34100	0/4	<2.25	ND	ND	4/4	<0.100	ND	ND	4/4
GW-2012	<28.0	ND	ND	4/4	10515	9860	11100	0/4	<2.25	ND	ND	4/4	<0.100	ND	ND	4/4
GW-2013	<28.0	ND	ND	4/4	13825	12600	16500	0/4	<2.25	ND	ND	4/4	<0.100	ND	0.110	3/4
GW-2014	<25.8	ND	ND	4/4	41300	39400	43900	0/4	<2.25	ND	2.60	3/4	<0.100	ND	ND	4/4
GW-2015	<28.0	ND	ND	4/4	70350	67300	76500	0/4	<2.25	ND	2.40	3/4	<0.100	ND	0.110	3/4
GW-2017	31.8	ND	44.5	1/4	157750	147000	167000	0/4	<2.25	ND	3.60	3/4	<0.100	ND	ND	4/4
GW-2018	<25.8	ND	33.3	2/4	37650	36600	39800	0/4	<2.25	ND	ND	4/4	<0.100	ND	ND	4/4
GW-2019	<25.8	ND	27.5	3/4	67000	61700	69700	0/4	62.9	30.0	93.1	0/4	<0.100	ND	ND	4/4
GW-2020	36.1	ND	58.7	1/3	26400	26300	27600	0/3	<2.33	ND	3.20	2/3	<0.100	ND	ND	3/3
GW-2021	<25.8	ND	ND	4/4	53375	47800	65400	0/4	128	52.3	240	0/4	<0.100	ND	0.100	3/4
GW-2022	<23.3	ND	26.5	3/4	48550	45700	49800	0/4	92.9	85.0	111	0/4	<0.100	ND	0.030	3/4

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Lithium µg/l				Magnesium µg/l				Manganese µg/l				Mercury µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2023	<25.8	ND	ND	4/4	34150	32900	37100	0/4	14.8	8.70	19.4	0/4	<0.100	ND	ND	4/4
GW-2024	<25.8	ND	ND	4/4	47950	46100	51400	0/4	53.8	45.8	58.3	0/4	<0.125	ND	ND	4/4
GW-2025	<28.0	ND	ND	4/4	36375	35600	37300	0/4	123	36.5	215	0/4	<0.100	ND	ND	4/4
GW-2026	<24.0*	ND	ND	4/4	35250*	32900	38200	0/4	85.3*	42.3	115	0/4	<0.100*	ND	0.110	3/4
GW-2027	<25.8	ND	ND	4/4	22350	21500	22900	0/4	295	93.1	425	0/4	<0.100	ND	ND	4/4
GW-2028	<28.0	ND	42.3	3/4	89500	88200	91300	0/4	325	275	388	0/4	<0.100	ND	ND	4/4
GW-2029	<25.8	ND	ND	4/4	49325	43300	53700	0/4	<2.25	ND	3.10	3/4	<0.100	ND	ND	4/4
GW-2030	<25.8	ND	ND	4/4	22700	20500	24600	0/4	6.83	5.70	8.90	0/4	<0.100	ND	ND	4/4
GW-2032	<24.0	ND	23.9	3/4	46775	42700	51600	0/4	<2.25	ND	2.20	3/4	<0.100	ND	0.120	3/4
GW-2033	<25.8	ND	ND	4/4	12588	7950	15800	0/4	<2.25	ND	2.00	3/4	<0.100	ND	ND	4/4
GW-2034	44.3	37.7	59.2	0/4	142250	120000	174000	0/4	3.20	ND	6.90	1/4	<0.100	ND	0.100	3/4
GW-2035	<31.5	ND	ND	2/2	22050	21600	22500	0/2	<2.00	ND	2.30	1/2	<0.100	ND	ND	3/3
GW-2036	<23.5	ND	ND	2/2	35550	33600	37500	0/2	<2.00	ND	2.30	1/2	<0.100	ND	ND	3/3
GW-2037	478	451	504	0/2	88750	87300	90200	0/2	101	96.9	106	0/2	2.07	1.30	2.60	0/3
GW-2038	584	575	593	0/2	277000	271000	283000	0/2	76.0	71.2	80.7	0/2	0.660	ND	1.04	1/3
GW-2039	<31.5	ND	ND	2/2	87250	82800	91700	0/2	<2.00	ND	2.30	1/2	<0.100	ND	ND	3/3
GW-2040	48.5	32.6	64.8	0/3	150333	122000	170000	0/3	171	93.0	288	0/3	<0.100	ND	ND	3/3
GW-2041	56.7	45.5	67.8	0/2	250000	227000	273000	0/2	359	299	419	0/2	0.147	ND	0.220	1/3
GW-2042	<31.5	ND	ND	2/2	56450	54900	58000	0/2	7.95	ND	14.9	1/2	<0.100	ND	ND	3/3

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Lithium µg/l				Magnesium µg/l				Manganese µg/l				Mercury µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2043	<30.7	ND	ND	3/3	62600	54000	69600	0/3	56.2	ND	156	1/3	<0.100	ND	ND	3/3
GW-3003	475	456	494	0/2	136000	131000	141000	0/2	3.40	3.30	3.50	0/2	<0.100	ND	ND	2/2
GW-3006	<27.5	ND	ND	2/2	48100	47300	48900	0/2	57.3	17.5	97.1	0/2	<0.100	ND	ND	2/2
GW-3008	232	204	259	0/2	137500	129000	146000	0/2	<2.50	ND	ND	2/2	1.50	1.30	1.70	0/2
GW-3009	<32.0	ND	ND	2/2	84050	80200	87900	0/2	12.2	10.6	13.8	0/2	<0.100	ND	ND	2/2
GW-3019	<25.8	ND	ND	4/4	38450	36000	42600	0/4	123	115	131	0/4	<0.100	ND	ND	4/4
GW-3023	810	735	929	0/4	72850	65500	85800	0/4	5.18	3.30	6.50	0/4	<0.100	ND	0.200	3/4
GW-4001	<24.0*	ND	ND	2/2	32000*	31900	32100	0/2	2.35*	ND	3.70	1/2	<0.100*	ND	ND	2/2
GW-4002	<32.0	ND	ND	2/2	29850	28200	31500	0/2	4.95	3.90	6.00	0/2	<0.150	ND	ND	2/2
GW-4003	<27.6	ND	ND	2/2	35100	33200	37000	0/2	<2.50	ND	ND	2/2	<0.100	ND	ND	2/2
GW-4004	<27.5	ND	ND	2/2	28600	27500	29700	0/2	<2.50	ND	ND	2/2	<0.100	ND	ND	2/2
GW-4005	<32.0	ND	37.0	1/2	28550	26800	30300	0/2	2.10	ND	3.20	1/2	<0.100	ND	ND	2/2
GW-4006	<24.0*	ND	31.7	1/2	21850*	21100	22600	0/2	<2.00*	ND	ND	2/2	<0.100*	ND	ND	2/2
GW-4007	<27.5	ND	ND	2/2	23400	22500	24300	0/2	32.2	20.6	43.8	0/2	<0.100	ND	ND	2/2
GW-4008	<27.5	ND	ND	2/2	31800	31000	32600	0/2	21.6	18.9	24.3	0/2	<0.100	ND	ND	2/2
GW-4009	31.8	ND	46.1	1/2	29850	29400	30300	0/2	<2.50	ND	ND	2/2	<0.100	ND	ND	2/2
GW-4010	33.0	ND	55.9	1/2	40750	40300	41200	0/2	<2.50	ND	ND	2/2	<0.100	ND	ND	2/2
GW-4011	61.3	51.4	71.1	0/2	44200	44200	—	0/2	<2.50	ND	ND	2/2	<0.100	ND	ND	2/2
GW-4012	<32.0	ND	39.9	1/2	34600	34100	35100	0/2	4.25	ND	7.50	1/2	<0.100	ND	ND	2/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Lithium µg/l				Magnesium µg/l				Manganese µg/l				Mercury µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-4013	42.8	ND	68.1	1/2	47900	47500	48300	0/2	<2.00	ND	2.00	1/2	<0.100	ND	ND	2/2
GW-4014	<32.0	ND	ND	2/2	42600	42400	42800	0/2	35.6	34.4	36.8	0/2	<0.100	ND	ND	2/2
GW-4015	<27.5	ND	ND	2/2	29450	29000	29900	0/2	<2.50	ND	2.70	1/2	<0.100	ND	ND	2/2
GW-4016	<27.5	ND	44.3	1/2	29850	28800	30900	0/2	59.6	55.1	64.1	0/2	<0.100	ND	ND	2/2
GW-4017	<27.5	ND	ND	2/2	39050	37900	40200	0/2	17.2	5.40	28.9	0/2	<0.100	ND	ND	2/2
GW-4018	<27.5	ND	ND	2/2	56000	55900	56100	0/2	<2.50	ND	ND	2/2	<0.100	ND	ND	2/2
GW-4019	32.6	ND	55.2	1/2	45000	43900	46100	0/2	<2.50	ND	ND	2/2	<0.100	ND	ND	2/2
GW-4020	<32.0	ND	ND	2/2	63050	62100	64000	0/2	82.2	51.3	113	0/2	<0.100	ND	ND	2/2
GW-4021	<35.0*	ND	ND	1/1	120000*	120000	—	0/1	11.5*	11.5	—	0/1	<0.100*	ND	ND	1/1
GW-4022	<28.0	ND	ND	4/4	44775	43200	49000	0/4	49.1	4.00	130	0/4	<0.100	ND	ND	4/4
GW-4023	<27.5	ND	36.5	1/2	42600	40000	45200	0/2	<2.50	ND	ND	2/2	<0.100	ND	ND	2/2
GW-FINW													0.410	0.410	—	0/1
GW-PW02	<22.7	ND	ND	3/3	14233	13700	15200	0/3	336	305	394	0/3	<0.100	ND	ND	3/3
GW-PW03													<0.100	ND	ND	1/1
GW-PW04													<0.100	ND	ND	1/1
GW-PW05													<0.100	ND	ND	1/1
GW-PW06													<0.100	ND	ND	1/1
GW-PW07													<0.100	ND	ND	1/1
GW-PW08													<0.100	ND	ND	1/1

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Lithium µg/l				Magnesium µg/l				Manganese µg/l				Mercury µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-PW09	27.6	ND	45.2	1/3	26567	25000	28300	0/3	390	366	422	0/3	<0.100	ND	ND	3/3
GW-RAWW													0.150	0.150	--	0/1
GW-RMW1	<20.0	ND	ND	2/2	27600	27100	28100	0/2	1390	1330	1430	0/2	<0.100	ND	ND	2/2
GW-RMW2	<20.0	ND	26.9	1/2	25350	25100	25600	0/2	911	837	984	0/2	<0.100	ND	ND	2/2
GW-RMW3																
GW-RMW4																

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Molybdenum µg/l				Nickel µg/l				Potassium µg/l				Selenium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1002	<20.3	ND	6.90	2/3	<15.5	ND	19.3	3/4	4298	4100	4460	0/4	<2.00	ND	2.60	1/3
GW-1004																
GW-1005	<20.3	ND	7.80	2/3	<15.50	ND	ND	4/4	9825	8360	12200	0/4	<2.00	ND	ND	3/3
GW-1006																
GW-1007																
GW-1008																
GW-1009																
GW-1010																
GW-1011																
GW-1012																
GW-1013	<40.0	ND	ND	1/1	<16.50	ND	ND	2/2	4810	4740	4880	0/2	<2.00	ND	ND	1/1
GW-1014	<27.5	ND	ND	2/2	<18.00	ND	ND	3/3	4037	3830	4140	0/3	<2.00	ND	ND	2/2
GW-1015																
GW-1016																
GW-1017																
GW-1018	<10.60	ND	7.10	1/2	<16.00	ND	ND	3/3	6697	5840	7600	0/3	<2.00	ND	2.00	1/2
GW-1019	<27.0	ND	ND	2/2	<17.3	ND	12.3	2/3	6257	4740	8190	0/3	<2.00	ND	ND	2/2
GW-1020																
GW-1021	<15.00	ND	ND	1/1	<20.0	ND	ND	2/2	6110	5930	6290	0/2	2.20	2.20	—	0/1

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Molybdenum µg/l				Nickel µg/l				Potassium µg/l				Selenium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1022	<10.50	ND	ND	2/2	<16.00	ND	ND	3/3	6380	4940	7310	0/3	<2.00	ND	ND	2/2
GW-1023																
GW-1024																
GW-1026																
GW-1027																
GW-1028	<15.00	ND	ND	1/1	<20.0	ND	ND	2/2	4590	4180	5000	0/2	<2.00	ND	ND	1/1
GW-1029																
GW-1030																
GW-1031																
GW-1032	<15.00	ND	ND	1/1	<20.0	ND	ND	2/2	4015	3870	4160	0/2	<2.00	ND	ND	1/1
GW-1033	<15.00	ND	ND	1/1	<20.0	ND	22.9	1/2	6145	5900	6390	0/2	2.90	2.90	—	0/1
GW-1034	<31.3	ND	ND	3/3	<16.50	ND	ND	4/4	2713	2200	3230	0/4	3.63	ND	8.90	2/3
GW-1035													<2.00	ND	ND	1/1
GW-1036													<2.00	ND	ND	1/1
GW-1037													<2.00	ND	ND	1/1
GW-1038													<2.00	ND	ND	1/1
GW-1039													<2.00	ND	ND	1/1
GW-2001	<30.0	ND	ND	2/2	<16.50	ND	ND	2/2	1535	1420	1650	0/2	<2.00	ND	2.70	1/2
GW-2002	<30.0	ND	ND	2/2	<16.50	ND	ND	2/2	7060	4880	9240	0/2	8.85	7.50	10.2	0/2

061994

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Molybdenum µg/l				Nickel µg/l				Potassium µg/l				Selenium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2003	<30.0	ND	ND	2/2	<16.50	ND	ND	2/2	8055	7830	8280	0/2	11.3	10.5	12.1	0/2
GW-2004	<20.3	ND	6.20	3/4	<15.50	ND	ND	4/4	1095	882	1310	0/4	<2.00	ND	ND	4/4
GW-2005	<16.00	ND	ND	4/4	<11.75	ND	12.3	3/4	2668	2200	3120	0/4	<1.75	ND	3.50	2/4
GW-2006	<24.0	ND	ND	5/5	79.0	65.5	92.6	0/5	9224	8280	10400	0/5	<2.00	ND	3.20	3/5
GW-2007	<43.8	ND	ND	4/4	<23.5	ND	ND	4/4	<1838	ND	2090	2/4	<2.75	ND	ND	4/4
GW-2008	<28.5	ND	ND	4/4	107	86.9	134	0/4	2458	1770	3140	0/4	<2.00	ND	ND	4/4
GW-2009	<43.8	ND	ND	4/4	<23.5	ND	ND	4/4	2205	ND	2320	1/4	<2.75	ND	ND	4/4
GW-2010	<16.00	ND	ND	4/4	46.8	36.8	60.8	0/4	2785	2610	3040	0/4	<1.750	ND	ND	4/4
GW-2011	<28.5	ND	ND	4/4	<16.50	ND	ND	4/4	1538	913	2310	0/4	<2.00	ND	2.90	3/4
GW-2012	<28.5	ND	ND	4/4	<16.50	ND	ND	4/4	1716	1450	2420	0/4	<2.00	ND	ND	4/4
GW-2013	<28.5	ND	ND	4/4	<16.50	ND	ND	4/4	2018	1320	2810	0/4	<2.00	ND	ND	4/4
GW-2014	<20.3	ND	ND	4/4	<15.50	ND	ND	4/4	4483	4280	4720	0/4	<2.00	ND	2.10	3/4
GW-2015	<28.5	ND	ND	4/4	<16.50	ND	ND	4/4	2730	2020	3190	0/4	<2.00	ND	2.90	2/4
GW-2017	<20.3	ND	17.7	2/4	<15.50	ND	ND	4/4	2490	2230	2780	0/4	<5.50	ND	ND	4/4
GW-2018	<20.3	ND	ND	4/4	<16.50	ND	ND	4/4	849	ND	1490	2/4	2.15	ND	5.60	3/4
GW-2019	40.1	ND	59.2	1/4	<15.50	ND	ND	4/4	4065	2760	4740	0/4	<2.00	ND	2.10	3/4
GW-2020	<25.0	ND	23.3	2/3	<18.00	ND	ND	3/3	2300	1890	2890	0/3	3.20	ND	5.50	1/3
GW-2021	<20.3	ND	ND	4/4	<15.5	ND	16.3	3/4	1178	852	1680	0/4	<2.00	ND	3.40	3/4
GW-2022	<24.3	ND	ND	4/4	<12.75	ND	0.400	3/4	1196	ND	1920	1/4	<1.750	ND	ND	4/4

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Molybdenum µg/l				Nickel µg/l				Potassium µg/l				Selenium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2023	<20.3	ND	9.90	3/4	<15.60	ND	10.8	3/4	<761	ND	1790	3/4	<2.00	ND	ND	4/4
GW-2024	<20.3	ND	ND	4/4	<15.50	ND	ND	4/4	<761	ND	1060	2/4	<2.00	ND	ND	4/4
GW-2025	<28.5	ND	ND	4/4	<16.50	ND	ND	4/4	1021	692	1250	0/4	<2.00	ND	ND	4/4
GW-2026	<20.0*	ND	6.10	3/4	<14.00*	ND	ND	4/4	<826*	ND	1180	2/4	<2.00*	ND	ND	4/4
GW-2027	<20.3	ND	8.00	3/4	<15.50	ND	ND	4/4	1188	683	1660	0/4	<2.00	ND	ND	4/4
GW-2028	<23.5	ND	ND	4/4	<16.50	ND	ND	4/4	<814	ND	1170	2/4	<2.00	ND	ND	4/4
GW-2029	<20.3	ND	ND	4/4	<15.50	ND	11.5	3/4	1465	1150	1740	0/4	<2.00	ND	ND	4/4
GW-2030	<20.3	ND	ND	4/4	<15.50	ND	ND	4/4	3653	3230	4280	0/4	<2.00	ND	ND	4/4
GW-2032	<20.0	ND	36.6	3/4	<15.00	ND	ND	4/4	2848	2260	3510	0/4	4.45	2.30	6.30	0/4
GW-2033	<20.3	ND	ND	4/4	<15.50	ND	ND	4/4	3248	2530	3860	0/4	3.13	ND	7.80	2/4
GW-2034	<28.5	ND	ND	4/4	38.8	ND	55.7	1/4	1965	1630	2230	0/4	<6.50	ND	3.90	3/4
GW-2035	<39.5	ND	ND	2/2	<13.00	ND	ND	2/2	<777	ND	ND	2/2	<2.00	ND	3.80	2/3
GW-2036	<22.5	ND	ND	2/2	<10.00	ND	ND	2/2	816	ND	1180	1/2	<2.00	ND	ND	3/3
GW-2037	<39.5	ND	ND	2/2	<13.0	ND	15.7	1/2	4025	4010	4040	0/2	3.57	2.10	5.00	0/3
GW-2038	<39.5	ND	ND	2/2	<13.00	ND	ND	2/2	6965	6460	7470	0/2	12.8	ND	16.1	1/3
GW-2039	43.6	ND	67.7	1/2	15.2	ND	24.4	1/2	1170	1150	1190	0/2	11.3	6.50	20.4	0/3
GW-2040	<33.0	ND	41.6	2/3	<15.0	ND	16.4	2/3	2567	1850	3620	0/3	5.00	2.50	7.10	0/3
GW-2041	<39.5	ND	ND	2/2	<13.0	ND	13.6	1/2	3320	2390	4260	0/2	51.4	37.2	64.7	0/3
GW-2042	<39.5	ND	ND	2/2	<13.00	ND	ND	2/2	949	697	1200	0/2	<2.00	ND	2.50	1/3

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Molybdenum µg/l				Nickel µg/l				Potassium µg/l				Selenium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2043	<33.0	ND	ND	3/3	<15.0	ND	26.2	2/3	<810	ND	1330	2/3	2.43	ND	3.30	1/3
GW-3003	<30.0	ND	ND	2/2	<16.50	ND	ND	2/2	9045	8920	9170	0/2	7.60	4.90	10.3	0/2
GW-3006	<27.5	ND	ND	2/2	<17.50	ND	ND	2/2	1017	ND	1620	1/2	<2.00	ND	ND	2/2
GW-3008	<27.5	ND	ND	2/2	<17.50	ND	ND	2/2	2410	2350	2470	0/2	14.6	14.5	14.6	0/2
GW-3009	<30.0	ND	ND	2/2	62.0	60.1	63.9	0/2	1710	1320	2100	0/2	3.15	2.30	4.00	0/2
GW-3019	<20.3	ND	ND	4/4	27.0	ND	81.1	3/4	1700	1490	1920	0/4	<2.00	ND	ND	4/4
GW-3023	204	190	224	0/4	<15.50	ND	ND	4/4	3183	2730	3620	0/4	9.05	ND	11.9	1/4
GW-4001	<13.00*	ND	ND	2/2	<13.50*	ND	ND	2/2	1880*	1770	1990	0/2	<2.00*	ND	2.00	1/2
GW-4002	<30.0	ND	ND	2/2	<16.50	ND	ND	2/2	<763	ND	704	1/2	<2.00	ND	ND	2/2
GW-4003	<27.5	ND	ND	2/2	<17.50	ND	ND	2/2	1225	1030	1420	0/2	2.16	ND	3.30	1/2
GW-4004	<27.5	ND	ND	2/2	<17.50	ND	ND	2/2	1011	992	1030	0/2	2.05	2.00	2.10	0/2
GW-4005	<30.0	ND	ND	2/2	<16.50	ND	ND	2/2	2165	1670	2660	0/2	<2.00	ND	ND	2/2
GW-4006	<13.00*	ND	ND	2/2	<13.60*	ND	ND	2/2	1215*	1030	1400	0/2	<2.00*	ND	ND	2/2
GW-4007	<27.5	ND	ND	2/2	<17.50	ND	ND	2/2	1930	1740	2120	0/2	2.45	ND	3.90	1/2
GW-4008	<27.5	ND	ND	2/2	<17.50	ND	ND	2/2	<738	ND	928	1/2	<2.00	ND	ND	2/2
GW-4009	<27.5	ND	ND	2/2	<17.50	ND	ND	2/2	17725	6950	28500	0/2	<2.00	ND	2.20	1/2
GW-4010	<27.5	ND	ND	2/2	<17.50	ND	ND	2/2	<738	ND	807	1/2	2.15	ND	3.30	1/2
GW-4011	<27.5	ND	ND	2/2	<17.50	ND	ND	2/2	7205	6860	7550	0/2	<2.00	ND	3.00	1/2
GW-4012	45.6	ND	71.2	1/2	<16.50	ND	ND	2/2	44850	21000	68700	0/2	<2.00	ND	ND	2/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Molybdenum µg/l				Nickel µg/l				Potassium µg/l				Selenium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-4013	<30.0	ND	ND	2/2	<16.50	ND	ND	2/2	5480	5280	5680	0/2	2.80	ND	4.60	1/2
GW-4014	<30.0	ND	ND	2/2	<16.50	ND	ND	2/2	<763	ND	ND	2/2	<2.00	ND	ND	2/2
GW-4015	<27.5	ND	ND	2/2	<17.50	ND	ND	2/2	1335	1330	1340	0/2	<2.00	ND	ND	2/2
GW-4016	43.2	20.8	65.6	0/2	<17.5	ND	21.3	1/2	1105	840	1370	0/2	<2.00	ND	ND	2/2
GW-4017	<27.5	ND	ND	2/2	<17.5	ND	14.2	1/2	1905	1140	2670	0/2	<2.00	ND	2.70	1/2
GW-4018	<27.5	ND	ND	2/2	<17.50	ND	ND	2/2	2235	1990	2480	0/2	<2.00	ND	ND	2/2
GW-4019	<27.5	ND	ND	2/2	<17.50	ND	ND	2/2	<738	ND	ND	2/2	<2.00	ND	ND	2/2
GW-4020	<30.0	ND	ND	2/2	<16.50	ND	ND	2/2	4005	4000	4010	0/2	<2.00	ND	ND	2/2
GW-4021	<40.0*	ND	ND	1/1	<14.00*	ND	ND	1/1	2250*	2250	--	0/1	<2.00*	ND	ND	1/1
GW-4022	<28.5	ND	34.2	3/4	<16.5	ND	26.7	3/4	1443	1170	1630	0/4	<2.00	ND	2.50	3/4
GW-4023	<27.5	ND	ND	2/2	<17.50	ND	ND	2/2	797	ND	1180	1/2	2.55	2.40	2.70	0/2
GW-FINW																
GW-PW02	<23.0	ND	ND	3/3	<18.00	ND	ND	3/3	4330	4270	4430	0/3	<2.00	ND	2.00	2/3
GW-PW03													<2.00	ND	ND	1/1
GW-PW04																
GW-PW05													<2.00	ND	ND	1/1
GW-PW06													<2.00	ND	ND	1/1
GW-PW07																
GW-PW08																

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Molybdenum µg/l				Nickel µg/l				Potassium µg/l				Selenium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-PW09	<24.7	ND	ND	3/3	<17.33	ND	ND	3/3	3353	2650	3720	0/3	<2.00	ND	ND	3/3
GW-RAWW																
GW-RMW1	<15.00	ND	ND	2/2	<21.0	ND	ND	2/2	5220	5220	—	0/2	<2.00	ND	ND	2/2
GW-RMW2	<15.00	ND	ND	2/2	<21.0	ND	ND	2/2	2985	2940	3030	0/2	<2.00	ND	ND	2/2
GW-RMW3																
GW-RMW4																

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Silicon µg/l				Silver µg/l				Sodium µg/l				Strontium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1002					<6.00	ND	ND	3/3	25975	24700	27600	0/4	363	302	400	0/4
GW-1004																
GW-1005					<6.00	ND	ND	3/3	19800	18200	20400	0/4	674	606	712	0/4
GW-1006																
GW-1007																
GW-1008																
GW-1009																
GW-1010																
GW-1011																
GW-1012																
GW-1013					<6.50	ND	ND	2/2	17500	17200	17800	0/2	463	449	477	0/2
GW-1014					<7.33	ND	ND	3/3	20933	17300	25600	0/3	459	432	489	0/3
GW-1015																
GW-1016																
GW-1017																
GW-1018					<6.00	ND	ND	2/2	25533	23200	27700	0/3	897	689	1010	0/3
GW-1019					<8.00	ND	ND	2/2	13433	13000	14100	0/3	854	753	920	0/3
GW-1020																
GW-1021					<9.00	ND	ND	1/1	14950	14200	15700	0/2	972	904	1040	0/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Silicon µg/l				Silver µg/l				Sodium µg/l				Strontium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1022					<6.00	ND	ND	2/2	18333	16300	22300	0/3	740	495	986	0/3
GW-1023																
GW-1024																
GW-1026																
GW-1027																
GW-1028					<6.00	ND	ND	2/2	14050	13800	14300	0/2	766	766	---	0/1
GW-1029																
GW-1030																
GW-1031																
GW-1032					<6.00	ND	ND	2/2	37450	35800	39100	0/2	526	526	---	0/1
GW-1033					<9.00	ND	ND	1/1	81350	78400	84300	0/2	628	588	668	0/2
GW-1034					<7.25	ND	ND	4/4	16275	15300	17500	0/4	305	246	372	0/4
GW-1035					<7.00	ND	ND	1/1								
GW-1036					<7.00	ND	ND	1/1								
GW-1037					<7.00	ND	ND	1/1								
GW-1038					<7.00	ND	ND	1/1								
GW-1039					<7.00	ND	ND	1/1								
GW-2001					<6.50	ND	ND	2/2	9480	9240	9720	0/2	119	112	126	0/2
GW-2002					<6.50	ND	ND	2/2	106400	93800	119000	0/2	357	295	418	0/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Silicon µg/l				Silver µg/l				Sodium µg/l				Strontium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2003					<6.50	ND	ND	2/2	129500	123000	136000	0/2	572	562	581	0/2
GW-2004	4880	4880	--	0/1	<6.25	ND	ND	4/4	11950	11100	12500	0/4	163	148	171	0/4
GW-2005					<5.00	ND	ND	4/4	24800	20700	27700	0/4	134	118	144	0/4
GW-2006					<6.40	ND	ND	5/5	101280	93800	109000	0/5	214	200	222	0/4
GW-2007					<8.00	ND	ND	4/4	6193	5850	6510	0/4	179	145	220	0/4
GW-2008					<7.25	ND	ND	4/4	12375	11600	13700	0/4	122	113	131	0/4
GW-2009					<8.00	ND	ND	4/4	39725	34500	43700	0/4	141	135	148	0/4
GW-2010					<5.00	ND	ND	4/4	49675	42400	54100	0/4	131	121	153	0/4
GW-2011					<7.25	ND	ND	4/4	7193	6840	7430	0/4	96.3	91.6	99.5	0/4
GW-2012					<7.25	ND	ND	4/4	49625	45000	58700	0/4	187	176	192	0/4
GW-2013					<7.25	ND	ND	4/4	89375	85600	91000	0/4	150	142	162	0/4
GW-2014					<6.25	ND	ND	4/4	36350	29600	42400	0/4	157	152	162	0/4
GW-2015					<7.25	ND	ND	4/4	28850	28000	29800	0/4	237	231	248	0/4
GW-2017					<6.25	ND	ND	4/4	38000	36600	38800	0/4	445	421	460	0/4
GW-2018					<6.25	ND	ND	4/4	44150	42300	46000	0/4	280	272	287	0/4
GW-2019					<6.26	ND	ND	4/4	35425	25100	42300	0/4	454	424	467	0/4
GW-2020					<7.33	ND	ND	3/3	99200	93500	105000	0/3	199	189	205	0/3
GW-2021					<6.25	ND	ND	4/4	9998	7620	12600	0/4	142	120	167	0/4
GW-2022					<6.00	ND	ND	4/4	6613	6170	6990	0/4	147	140	161	0/4

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Silicon µg/l				Silver µg/l				Sodium µg/l				Strontium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2023					<6.25	ND	ND	4/4	8733	6820	11800	0/4	117	104	137	0/4
GW-2024					<6.25	ND	ND	4/4	6353	6100	6770	0/4	169*	160	176	0/3
GW-2025					<7.25	ND	ND	4/4	5168	3860	6760	0/4	129	121	134	0/4
GW-2026					<5.50*	ND	ND	4/4	6568*	5860	7320	0/4	139*	126	162	0/3
GW-2027					<6.25	ND	ND	4/4	5870	5460	6220	0/4	124	113	134	0/4
GW-2028					<7.25	ND	ND	4/4	20450	18800	21800	0/4	239	227	254	0/4
GW-2029	5370	5370	--	0/1	<6.25	ND	ND	4/4	7853	7410	8820	0/4	195	168	212	0/4
GW-2030					<6.25	ND	ND	4/4	49675	44400	56200	0/4	177	169	186	0/4
GW-2032					<6.50	ND	ND	4/4	63350	58200	69000	0/4	322	294	349	0/4
GW-2033					<6.25	ND	ND	4/4	87225	82400	95900	0/4	135	95.4	154	0/4
GW-2034					<7.25	ND	ND	4/4	43450	41300	45200	0/4	421	366	482	0/4
GW-2035					<7.33	ND	ND	3/3	5880	5650	6110	0/2	81.1	80.5	81.7	0/2
GW-2036					<6.33	ND	ND	3/3	18250	17100	19400	0/2	163	148	177	0/2
GW-2037					<7.33	ND	ND	3/3	227500	222000	233000	0/2	550	522	577	0/2
GW-2038					<7.33	ND	ND	3/3	345500	340000	351000	0/2	2230	2200	2260	0/2
GW-2039					<7.33	ND	10.9	2/3	42200	40200	44200	0/2	466	459	473	0/2
GW-2040					<6.67	ND	ND	3/3	51033	48600	53200	0/3	800	701	882	0/3
GW-2041					<7.33	ND	ND	3/3	388000	351000	425000	0/2	2375	2080	2670	0/2
GW-2042					<7.33	ND	ND	3/3	70550	69300	71800	0/2	355	342	368	0/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Silicon µg/l				Silver µg/l				Sodium µg/l				Strontium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2043					<6.67	ND	ND	3/3	25100	23500	26400	0/3	280	269	299	0/3
GW-3003					<6.50	ND	ND	2/2	163000	162000	164000	0/2	574	566	581	0/2
GW-3006					<7.50	ND	ND	2/2	17500	17000	18000	0/2	200	191	209	0/2
GW-3008					<7.50	ND	ND	2/2	209000	193000	225000	0/2	1305	1270	1340	0/2
GW-3009					<6.50	ND	ND	2/2	45200	39000	51400	0/2	336	303	368	0/2
GW-3019					<6.25	ND	ND	4/4	6888	6490	7610	0/4	105	98.5	114	0/4
GW-3023					<6.25	ND	ND	4/4	222250	200000	261000	0/4	608	553	680	0/4
GW-4001					<5.00*	ND	ND	2/2	23950*	23600	24300	0/2	86.7*	86.7	---	0/1
GW-4002					<6.50	ND	ND	2/2	7680	7380	7980	0/2	141	103	179	0/2
GW-4003					<7.50	ND	ND	2/2	9365	9020	9710	0/2	111	105	116	0/2
GW-4004					<7.50	ND	ND	2/2	9530	9290	9770	0/2	89.3	83.8	94.8	0/2
GW-4005					<6.50	ND	ND	2/2	8235	7820	8650	0/2	157	140	173	0/2
GW-4006					<5.00*	ND	ND	2/2	7590*	7370	7810	0/2	69.5*	69.5	---	0/1
GW-4007					<7.50	ND	ND	2/2	23650	23300	24000	0/2	105	105	---	0/1
GW-4008					<7.50	ND	ND	2/2	3325	3280	3370	0/2	89.9	88.1	91.6	0/2
GW-4009					<7.50	ND	ND	2/2	19050	14500	23600	0/2	116	111	121	0/2
GW-4010					<7.50	ND	ND	2/2	13850	13800	13900	0/2	124	122	126	0/2
GW-4011					<7.50	ND	ND	2/2	66750	66500	67000	0/2	373	368	377	0/2
GW-4012					<6.50	ND	ND	2/2	47950	42900	53000	0/2	105	51.9	159	0/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Silicon µg/l				Silver µg/l				Sodium µg/l				Strontium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-4013					<6.50	ND	ND	2/2	30150	29200	31100	0/2	146	142	149	0/2
GW-4014					<6.50	ND	ND	2/2	5960	5820	6100	0/2	164	163	164	0/2
GW-4015					<7.50	ND	ND	2/2	7865	7590	8140	0/2	69.1	65.6	72.6	0/2
GW-4016					<7.50	ND	ND	2/2	9460	9020	9900	0/2	121	100	141	0/2
GW-4017					<7.50	ND	ND	2/2	8965	8500	9430	0/2	128	124	131	0/2
GW-4018					<7.50	ND	ND	2/2	8680	8420	8940	0/2	119	116	121	0/2
GW-4019					<7.50	ND	ND	2/2	9140	8870	9410	0/2	174	174	---	0/1
GW-4020					<6.50	ND	ND	2/2	22500	20200	24800	0/2	223	209	236	0/2
GW-4021					<6.00*	ND	ND	1/1	15700*	15700	---	0/1	229*	229	---	0/1
GW-4022					<7.25	ND	ND	4/4	11350	10700	12400	0/4	218	208	234	0/4
GW-4023					<7.50	ND	ND	2/2	57050	55900	58200	0/2	173	167	178	0/2
GW-FINW																
GW-PW02					<8.33	ND	ND	3/3	29100	21200	33800	0/3	350	326	370	0/3
GW-PW03					<9.00	ND	ND	1/1								
GW-PW04																
GW-PW05					<9.00	ND	ND	1/1								
GW-PW06					<9.00	ND	ND	1/1								
GW-PW07																
GW-PW08																

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Silicon µg/l				Silver µg/l				Sodium µg/l				Strontium µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-PW09					<7.67	ND	ND	3/3	7433	6950	7810	0/3	548	508	569	0/3
GW-RAWW																
GW-RMW1					<9.00	ND	ND	2/2	13350	13200	13500	0/2	784	748	819	0/2
GW-RMW2					<9.00	ND	ND	2/2	7830	7690	7970	0/2	542	511	573	0/2
GW-RMW3																
GW-RMW4																

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Thallium µg/l				Vanadium µg/l				Zinc µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1002	<3.67	ND	ND	3/3	21.2	13.2	25.3	0/3	16.9	ND	30.4	1/3
GW-1004												
GW-1005	<3.67	ND	ND	3/3	22.1	ND	33.3	1/3	22.7	ND	45.8	1/3
GW-1006												
GW-1007												
GW-1008												
GW-1009												
GW-1010												
GW-1011												
GW-1012												
GW-1013	<4.00	ND	ND	1/1	21.9	21.9	---	0/1	<9.00	ND	ND	1/1
GW-1014	<4.50	ND	ND	2/2	13.9	ND	24.3	1/2	6.65	ND	8.80	1/2
GW-1015												
GW-1016												
GW-1017												
GW-1018	<2.00	ND	ND	2/2	11.3	ND	20.1	1/2	10.3	6.70	13.9	0/2
GW-1019	<2.00	ND	ND	2/2	<5.00	ND	ND	2/2	7.25	6.40	8.10	0/2
GW-1020												
GW-1021	<2.00	ND	ND	1/1	14.0	14.0	---	0/1	<3.00	ND	ND	1/1

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Thallium µg/l				Vanadium µg/l				Zinc µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1022	<2.00	ND	ND	2/2	13.3	ND	23.0	1/2	7.10	5.10	9.10	0/2
GW-1023												
GW-1024												
GW-1026												
GW-1027												
GW-1028	<5.00	ND	ND	1/1	10.5	10.5	---	0/1	27.2	27.2	---	0/1
GW-1029												
GW-1030												
GW-1031												
GW-1032	<5.00	ND	ND	1/1	19.8	19.8	---	0/1	7.80	7.80	---	0/1
GW-1033	<2.00	ND	ND	1/1	<7.00	ND	ND	1/1	16.9	16.9	---	0/1
GW-1034	<2.67	ND	ND	3/3	16.8	ND	24.8	1/3	9.56	ND	17.5	1/3
GW-1035												
GW-1036												
GW-1037												
GW-1038												
GW-1039												
GW-2001	<4.00	ND	ND	1/1	9.75	ND	16.0	1/2	<8.50	ND	11.1	1/2
GW-2002	<4.00	ND	ND	1/1	24.9	24.2	25.6	0/2	<8.50	ND	ND	2/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Thallium µg/l				Vanadium µg/l				Zinc µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2003	<4.00	ND	ND	1/1	31.7	28.2	35.2	0/2	<8.50	ND	ND	2/2
GW-2004	<3.67	ND	2.00	2/3	14.4	13.3	15.3	0/4	<5.75	ND	11.0	3/4
GW-2005	<3.67	ND	ND	3/3	15.7	12.1	17.4	0/4	18.1	6.40	31.7	0/4
GW-2006	<7.75	ND	ND	4/4	11.2	ND	15.6	1/5	13.0	9.20	21.1	0/5
GW-2007	<6.33	ND	ND	3/3	<18.3	ND	14.1	1/4	11.2	ND	18.5	1/4
GW-2008	<3.67	ND	ND	3/3	10.7	3.20	17.4	0/4	23.5	ND	72.9	1/4
GW-2009	<6.33	ND	ND	3/3	<18.3	ND	17.7	1/4	16.2	ND	37.3	2/4
GW-2010	<3.67	ND	ND	3/3	12.6	10.4	16.0	0/4	7.80	ND	12.9	2/4
GW-2011	<3.67	ND	ND	3/3	17.1	ND	23.2	1/4	12.1	ND	22.4	1/4
GW-2012	<3.67	ND	ND	3/3	13.6	ND	28.6	2/4	11.1	ND	28.9	2/4
GW-2013	<3.67	ND	ND	3/3	9.38	ND	20.4	2/4	14.1	ND	30.6	1/4
GW-2014	<3.67	ND	ND	3/3	18.2	11.9	27.6	0/4	16.0	ND	29.2	1/4
GW-2015	<3.25	ND	ND	4/4	20.9	14.0	28.7	0/4	12.1	ND	19.6	1/4
GW-2017	<3.67	ND	2.30	2/3	35.1	32.9	38.4	0/4	8.06	ND	14.0	1/4
GW-2018	<3.67	ND	ND	3/3	11.7	ND	20.9	2/4	9.13	ND	15.4	1/4
GW-2019	<2.67	ND	ND	3/3	9.88	ND	18.7	1/4	8.35	ND	13.1	2/4
GW-2020	<2.67	ND	ND	3/3	19.8	8.70	33.1	0/3	12.4	ND	24.8	1/3
GW-2021	<3.25	ND	ND	4/4	12.2	ND	15.9	1/4	12.5	ND	18.3	1/4
GW-2022	<2.67	ND	ND	3/3	13.6	ND	26.0	1/4	32.4	1.50	72.2	0/4

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Thallium µg/l				Vanadium µg/l				Zinc µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2023	<2.50	ND	ND	4/4	17.6	3.20	30.2	0/4	7.96	ND	21.9	3/4
GW-2024	<2.50	ND	ND	4/4	14.7	ND	38.5	1/4	7.05	ND	11.7	2/4
GW-2025	<2.67	ND	ND	3/3	10.2	ND	27.1	2/4	<5.75	ND	9.70	2/4
GW-2026	<2.00*	ND	ND	3/3	8.33*	5.30	11.5	0/4	12.9*	6.00	26.2	0/4
GW-2027	<2.50	ND	ND	4/4	9.10	ND	16.2	1/4	10.6	ND	18.5	1/4
GW-2028	<3.25	ND	ND	4/4	17.0	ND	26.0	1/4	12.9	ND	34.1	2/4
GW-2029	<3.67	ND	ND	3/3	12.7	10.9	15.2	0/4	33.9	ND	60.7	1/4
GW-2030	<2.50	ND	ND	4/4	18.3	11.4	32.9	0/4	20.9	ND	47.6	1/4
GW-2032	<2.00	ND	ND	4/4	14.4	ND	19.4	1/4	14.5	ND	21.0	1/4
GW-2033	<2.50	ND	ND	4/4	12.9	9.80	18.8	0/4	16.4	ND	25.2	1/4
GW-2034	<3.67	ND	ND	3/3	20.4	ND	43.0	1/4	62.8	39.6	131	0/4
GW-2035	<3.00	ND	ND	2/2	<6.00	ND	ND	2/2	63.5	9.00	118	0/2
GW-2036	<2.00	ND	ND	2/2	5.00	ND	8.50	1/2	19.3	7.10	31.4	0/2
GW-2037	<3.00	ND	ND	2/2	27.9	ND	54.2	1/2	7.60	ND	10.7	1/2
GW-2038	<3.00	ND	ND	2/2	50.6	ND	99.6	1/2	11.3	10.1	12.4	0/2
GW-2039	<3.00	ND	ND	2/2	19.5	ND	37.5	1/2	19.1	11.9	26.3	0/2
GW-2040	<2.67	ND	ND	3/3	26.5	4.30	57.4	0/3	10.4	ND	14.8	1/3
GW-2041	<3.00	ND	ND	2/2	54.5	3.00	106	0/2	11.7	10.5	12.9	0/2
GW-2042	<3.00	ND	ND	2/2	17.7	ND	33.9	1/2	<6.00	ND	4.20	1/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Thallium µg/l				Vanadium µg/l				Zinc µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2043	<2.67	ND	ND	3/3	14.2	ND	33.9	1/3	<6.67	ND	8.40	1/3
GW-3003	<3.00	ND	ND	2/2	42.0	37.5	46.5	0/2	8.60	ND	13.2	1/2
GW-3006	<4.50	ND	ND	2/2	16.9	11.3	22.4	0/2	14.1	ND	23.6	1/2
GW-3008	<4.50	ND	ND	2/2	33.7	23.4	43.9	0/2	15.9	ND	30.3	1/2
GW-3009	<3.00	ND	ND	2/2	10.8	ND	17.1	1/2	45.9	14.9	76.8	0/2
GW-3019	<2.50	ND	ND	4/4	<6.50	ND	4.60	3/4	22.5	ND	45.2	1/4
GW-3023	<3.25	ND	ND	4/4	34.5	24.1	41.5	0/4	10.6	ND	19.9	2/4
GW-4001	<2.00*	ND	ND	1/1	10.7*	9.10	12.2	0/2	9.00*	8.00	10.0	0/2
GW-4002	<3.00	ND	ND	2/2	10.2	ND	16.8	1/2	87.6	13.1	162	0/2
GW-4003	<4.50	ND	ND	2/2	10.1	8.30	11.9	0/2	12.0	9.70	14.2	0/2
GW-4004	<3.00	ND	ND	2/2	10.6	7.60	13.6	0/2	13.2	10.6	15.8	0/2
GW-4005	<3.00	ND	ND	2/2	13.9	10.5	17.3	0/2	<8.50	ND	10.9	1/2
GW-4006	<2.00*	ND	ND	1/1	7.35*	6.10	8.60	0/2	23.8*	11.7	35.9	0/2
GW-4007	<4.50	ND	ND	2/2	9.60	ND	15.7	1/2	6.15	ND	7.80	1/2
GW-4008	<3.00	ND	ND	2/2	<8.00	ND	11.1	1/2	10.5	ND	16.5	1/2
GW-4009	<3.00	ND	ND	2/2	<8.00	ND	11.5	1/2	25.0	20.7	29.2	0/2
GW-4010	<12.00	ND	ND	2/2	14.4	ND	25.2	1/2	56.3	ND	108	1/2
GW-4011	<3.00	ND	ND	2/2	25.0	23.7	26.2	0/2	<6.00	ND	7.50	1/2
GW-4012	<12.00	ND	ND	2/2	9.15	8.80	9.50	0/2	13.6	12.1	15.0	0/2

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Thallium µg/l				Vanadium µg/l				Zinc µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-4013	<3.00	ND	ND	2/2	23.8	19.0	28.5	0/2	10.9	ND	17.8	1/2
GW-4014	<3.00	ND	ND	2/2	22.3	19.2	25.3	0/2	<8.50	ND	9.40	1/2
GW-4015	<4.50	ND	ND	2/2	9.95	ND	16.4	1/2	20.6	14.9	26.3	0/2
GW-4016	<4.50	ND	ND	2/2	19.9	ND	36.2	1/2	25.9	22.6	29.1	0/2
GW-4017	<3.00	ND	ND	2/2	10.9	ND	18.2	1/2	30.1	12.0	48.2	0/2
GW-4018	<3.00	ND	ND	2/2	12.4	12.3	12.5	0/2	10.5	ND	16.5	1/2
GW-4019	<4.50	ND	ND	2/2	15.6	10.2	21.0	0/2	6.50	ND	8.50	1/2
GW-4020	<3.00	ND	ND	2/2	18.8	9.50	28.0	0/2	<8.50	ND	10.2	1/2
GW-4021	<4.00*	ND	ND	1/1	35.9*	35.9	—	0/1	9.30*	9.30	—	0/1
GW-4022	<2.50	ND	ND	4/4	11.1	ND	28.3	2/4	38.0	6.80	80.1	0/4
GW-4023	<3.00	ND	ND	2/2	21.9	20.6	23.2	0/2	12.6	ND	20.7	1/2
GW-FINW												
GW-PW02	<4.00	ND	ND	3/3	<5.67	ND	ND	3/3	10.5	6.40	13.6	0/3
GW-PW03												
GW-PW04												
GW-PW05												
GW-PW06												
GW-PW07												
GW-PW08												

TABLE A-3 Geochemical Concentrations for Groundwater, 1993 (Continued)

Location	Thallium µg/l				Vanadium µg/l				Zinc µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-PW09	<3.00	ND	ND	3/3	10.2	ND	18.1	1/3	36.7	20.6	50.9	0/3
GW-RAWW												
GW-RMW1	<3.50	ND	ND	2/2	12.0	8.50	15.5	0/2	31.1	27.0	35.2	0/2
GW-RMW2	<3.50	ND	ND	2/2	12.4	10.5	14.2	0/2	25.0	21.9	28.0	0/2
GW-RMW3												
GW-RMW4												

TABLE A-4 Nitroaromatic Concentrations for Groundwater, 1993

Location	1,3,5-Trinitrobenzene µg/l				1,3-Dinitrobenzene µg/l				2,4,6-Trinitrotoluene µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1002	1269	800	1960	0/12	0.639	ND	0.880	1/12	224	150	370	0/12
GW-1004	5.19	0.760	10.0	0/12	<0.133	ND	ND	12/12	12.2	1.87	27.0	0/12
GW-1005	<0.089	ND	ND	9/9	<0.147	ND	ND	9/9	<0.113	ND	ND	9/9
GW-1006	57.0	32.0	85.0	0/4	<0.090	ND	ND	4/4	10.4	4.60	14.0	0/4
GW-1007	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-1008	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	0.125	0.120	0.130	0/2
GW-1009	<0.030	ND	ND	3/3	<0.090	ND	ND	3/3	<0.030	ND	ND	3/3
GW-1010	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-1011	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-1012	<0.030	ND	ND	6/6	<0.090	ND	ND	6/6	<0.030	ND	ND	6/6
GW-1013	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-1014	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-1015	43.2	15.0	80.0	0/6	0.242	0.130	0.440	0/6	10.9	7.00	16.0	0/6
GW-1016	3.34	1.50	5.40	0/5	<0.090	ND	ND	5/5	0.998	0.550	1.60	0/5
GW-1017	<0.295	ND	ND	2/2	<0.350	ND	ND	2/2	<0.405	ND	ND	2/2
GW-1018	<0.207	ND	ND	3/3	<0.263	ND	ND	3/3	<0.280	ND	ND	3/3
GW-1019	<0.207	ND	ND	3/3	<0.263	ND	ND	3/3	<0.280	ND	ND	3/3
GW-1020	<0.207	ND	ND	3/3	<0.263	ND	ND	3/3	<0.280	ND	ND	3/3
GW-1021	<0.295	ND	ND	2/2	<0.350	ND	ND	2/2	<0.405	ND	ND	2/2

TABLE A-4 Nitroaromatic Concentrations for Groundwater, 1993 (Continued)

Location	1,3,5-Trinitrobenzene µg/l				1,3-Dinitrobenzene µg/l				2,4,6-Trinitrotoluene µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1022	<0.207	ND	ND	3/3	<0.263	ND	ND	3/3	<0.280	ND	ND	3/3
GW-1023	<0.295	ND	ND	2/2	<0.350	ND	ND	2/2	<0.405	ND	ND	2/2
GW-1024	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-1026	<0.030	ND	ND	7/7	<0.090	ND	ND	7/7	<0.030	ND	ND	7/7
GW-1027	0.341	ND	0.560	1/7	<0.090	ND	ND	7/7	23.4	14.0	52.0	0/7
GW-1028	<0.030	ND	ND	3/3	<0.090	ND	ND	3/3	<0.030	ND	ND	3/3
GW-1029	<0.106	ND	0.073	6/7	<0.163	ND	ND	7/7	<0.137	ND	ND	7/7
GW-1030	0.166	ND	0.460	4/9	<0.147	ND	ND	9/9	2.01	ND	9.50	1/9
GW-1031	<0.163	ND	ND	4/4	<0.218	ND	ND	4/4	<0.218	ND	ND	4/4
GW-1032	5.38	ND	16.0	1/3	<0.090	ND	ND	3/3	16.6	0.760	48.0	0/3
GW-1033	<0.207	ND	ND	3/3	<0.263	ND	ND	3/3	<0.280	ND	ND	3/3
GW-1034	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-1035	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-1036	<0.030	ND	ND	5/5	<0.090	ND	ND	5/5	<0.030	ND	ND	5/5
GW-1037	<0.030	ND	ND	5/5	<0.090	ND	ND	5/5	<0.030	ND	ND	5/5
GW-1038	<0.030	ND	ND	5/5	<0.090	ND	ND	5/5	<0.030	ND	ND	5/5
GW-1039	<0.030	ND	ND	5/5	<0.090	ND	ND	5/5	<0.030	ND	ND	5/5
GW-2001	0.049	0.041	0.064	0/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-2002	<0.030	ND	0.029	2/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4

TABLE A-4 Nitroaromatic Concentrations for Groundwater, 1993 (Continued)

Location	1,3,5-Trinitrobenzene µg/l				1,3-Dinitrobenzene µg/l				2,4,6-Trinitrotoluene µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2003	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-2004	<0.030*	ND	ND	1/1	<0.090*	ND	ND	1/1	<0.030*	ND	ND	1/1
GW-2005	<0.030*	ND	ND	3/3	<0.090*	ND	ND	3/3	<0.030*	ND	ND	3/3
GW-2006	11.3	10.0	12.0	0/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-2007	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2008	1.03	0.800	1.20	0/4	<0.090	ND	0.064	3/4	<0.030	ND	0.032	2/4
GW-2009	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-2010	0.220	ND	0.210	1/4	<0.220	ND	ND	4/4	0.443	ND	0.480	1/4
GW-2011	0.560	0.520	0.600	0/4	<0.090	ND	ND	4/4	0.051	ND	0.160	3/4
GW-2012	1.90	1.80	2.00	0/4	<0.090	ND	ND	4/4	0.620	0.560	0.720	0/4
GW-2013	1.17	0.850	1.70	0/3	<0.090	ND	ND	3/3	0.079	0.026	0.170	0/3
GW-2014	3.50	3.00	4.00	0/4	<0.090	ND	0.091	2/4	0.041	ND	0.056	1/4
GW-2015	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2017	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-2018	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2019	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2020	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2021	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2022	<0.030*	ND	ND	1/1	<0.090*	ND	ND	1/1	<0.030*	ND	ND	1/1

TABLE A-4 Nitroaromatic Concentrations for Groundwater, 1993 (Continued)

Location	1,3,5-Trinitrobenzene µg/l				1,3-Dinitrobenzene µg/l				2,4,6-Trinitrotoluene µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2023	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2024	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2025	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2026	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2027	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2028	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2029	<0.030*	ND	ND	1/1	<0.090*	ND	ND	1/1	<0.030*	ND	ND	1/1
GW-2030	9.33	9.00	9.50	0/3	<0.090	ND	ND	3/3	13.3	12.0	14.0	0/3
GW-2032	4.23	4.00	4.50	0/4	<0.090	ND	ND	4/4	7.75	7.00	8.50	0/4
GW-2033	3.53	0.230	7.20	0/4	<0.090	ND	ND	4/4	0.724	0.084	1.40	0/4
GW-2034	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-2035	<0.030	ND	ND	5/5	<0.090	ND	ND	5/5	<0.030	ND	ND	5/5
GW-2036	<0.284	ND	ND	5/5	<0.134	ND	ND	5/5	<0.284	ND	ND	5/5
GW-2037	0.202	0.170	0.230	0/5	<0.090	ND	ND	5/5	<0.030	ND	ND	5/5
GW-2038	0.229	0.190	0.260	0/5	<0.090	ND	ND	5/5	<0.030	ND	ND	5/5
GW-2039	<0.030	ND	ND	5/5	<0.090	ND	ND	5/5	<0.030	ND	ND	5/5
GW-2040	<0.030	ND	ND	5/5	<0.090	ND	ND	5/5	<0.030	ND	ND	5/5
GW-2041	<0.030	ND	ND	5/5	<0.090	ND	ND	5/5	<0.030	ND	ND	5/5
GW-2042	<0.030	ND	ND	5/5	<0.090	ND	ND	5/5	<0.030	ND	ND	5/5

TABLE A-4 Nitroaromatic Concentrations for Groundwater, 1993 (Continued)

Location	1,3,5-Trinitrobenzene µg/l				1,3-Dinitrobenzene µg/l				2,4,6-Trinitrotoluene µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2043	<0.030	ND	0.019	3/5	<0.090	ND	ND	5/5	<0.030	ND	ND	5/5
GW-3003	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-3006	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-3008	<0.030	ND	ND	3/3	<0.090	ND	ND	3/3	<0.030	ND	ND	3/3
GW-3009	0.243	0.150	0.400	0/3	<0.090	ND	ND	3/3	<0.030	ND	ND	3/3
GW-3019	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-3023	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	0.050	ND	0.096	2/4
GW-4001	64.8*	54.0	75.0	0/4	<0.090*	ND	ND	4/4	2.00*	1.80	2.40	0/4
GW-4002	0.198	0.072	0.490	0/4	<0.090	ND	ND	4/4	1.14	0.600	2.00	0/4
GW-4003	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4004	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4005	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4006	14.2	9.91	19.0	0/4	<0.218	ND	ND	4/4	<0.218	ND	ND	4/4
GW-4007	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4008	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4009	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4010	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4011	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4012	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2

TABLE A-4 Nitroaromatic Concentrations for Groundwater, 1993 (Continued)

Location	1,3,5-Trinitrobenzene µg/l				1,3-Dinitrobenzene µg/l				2,4,6-Trinitrotoluene µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-4013	37.5	32.0	50.0	0/4	<0.090	ND	ND	4/4	0.050	0.038	0.069	0/4
GW-4014	0.580	0.560	0.600	0/2	<0.090	ND	ND	2/2	0.032	0.026	0.038	0/2
GW-4015	1.70	1.20	2.20	0/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4016	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4017	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4018	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4019	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4020	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4021	<0.030*	ND	ND	1/1	<0.090*	ND	ND	1/1	<0.030*	ND	ND	1/1
GW-4022	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4023	0.120	0.120	---	0/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-FINW	<0.030	ND	ND	3/3	<0.090	ND	ND	3/3	<0.030	ND	ND	3/3
GW-PW02	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-PW03	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-PW04	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-PW05	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-PW06	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-PW07	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-PW08	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2

TABLE A-4 Nitroaromatic Concentrations for Groundwater, 1993 (Continued)

Location	1,3,5-Trinitrobenzene µg/l				1,3-Dinitrobenzene µg/l				2,4,6-Trinitrotoluene µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-PW09	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-RAWW	<0.030	ND	ND	4/4	<0.090	ND	ND	4/4	<0.030	ND	ND	4/4
GW-RMW1	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-RMW2	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-RMW3	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2
GW-RMW4	<0.030	ND	ND	2/2	<0.090	ND	ND	2/2	<0.030	ND	ND	2/2

TABLE A-4 Nitroaromatic Concentrations for Groundwater, 1993 (Continued)

Location	2,4-Dinitrotoluene µg/l				2,6-Dinitrotoluene µg/l				Nitrobenzene µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1002	0.262	ND	0.360	1/12	40.0	18.0	111	0/12	<0.121	ND	ND	12/12
GW-1004	2.17	0.190	4.60	0/12	3.33	0.320	5.80	0/12	<0.121	ND	ND	12/12
GW-1005	0.099	ND	0.110	1/9	0.229	0.012	1.91	0/9	<0.151	ND	ND	9/9
GW-1006	0.173	0.120	0.220	0/4	1.45	1.20	1.90	0/4	<0.030	ND	ND	4/4
GW-1007	<0.030	ND	ND	2/2	0.012	ND	0.018	1/2	<0.030	ND	ND	2/2
GW-1008	<0.030	ND	ND	2/2	0.053	0.049	0.057	0/2	<0.030	ND	ND	2/2
GW-1009	<0.030	ND	ND	3/3	<0.010	ND	ND	3/3	<0.030	ND	ND	3/3
GW-1010	<0.030	ND	ND	4/4	<0.010	ND	ND	4/4	<0.030	ND	ND	4/4
GW-1011	<0.030	ND	ND	4/4	<0.010	ND	ND	4/4	<0.030	ND	ND	4/4
GW-1012	<0.030	ND	ND	6/6	<0.010	ND	ND	6/6	<0.030	ND	ND	6/6
GW-1013	<0.030	ND	ND	4/4	<0.010	ND	ND	4/4	<0.030	ND	ND	4/4
GW-1014	<0.030	ND	0.023	3/4	<0.010	ND	0.005	3/4	<0.030	ND	ND	4/4
GW-1015	0.062	0.046	0.083	0/6	0.395	0.280	0.530	0/6	<0.030	ND	ND	6/6
GW-1016	<0.030	ND	ND	5/5	0.071	0.053	0.092	0/5	<0.030	ND	ND	5/5
GW-1017	<0.315	ND	ND	2/2	<0.280	ND	ND	2/2	<0.580	ND	ND	2/2
GW-1018	<0.220	ND	ND	3/3	<0.190	ND	ND	3/3	<0.397	ND	ND	3/3
GW-1019	<0.220	ND	ND	3/3	<0.190	ND	ND	3/3	<0.397	ND	ND	3/3
GW-1020	<0.220	ND	ND	3/3	<0.190	ND	ND	3/3	<0.397	ND	ND	3/3
GW-1021	<0.315	ND	ND	2/2	<0.280	ND	ND	2/2	<0.580	ND	ND	2/2

TABLE A-4 Nitroaromatic Concentrations for Groundwater, 1993 (Continued)

Location	2,4-Dinitrotoluene µg/l				2,6-Dinitrotoluene µg/l				Nitrobenzene µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1022	<0.220	ND	ND	3/3	<0.190	ND	ND	3/3	<0.397	ND	ND	3/3
GW-1023	<0.315	ND	ND	2/2	<0.280	ND	ND	2/2	<0.580	ND	ND	2/2
GW-1024	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-1026	<0.030	ND	ND	7/7	<0.010	ND	ND	7/7	<0.030	ND	ND	7/7
GW-1027	7.63	1.60	26.0	0/7	4.24	2.90	7.20	0/7	<0.030	ND	ND	7/7
GW-1028	<0.030	ND	ND	3/3	<0.010	ND	ND	3/3	<0.030	ND	ND	3/3
GW-1029	<0.110	ND	ND	7/7	<0.087	ND	ND	7/7	<0.185	ND	ND	7/7
GW-1030	0.134	ND	0.170	1/9	0.447	ND	1.20	1/9	<0.151	ND	ND	9/9
GW-1031	<0.170	ND	ND	4/4	<0.145	ND	ND	4/4	<0.303	ND	ND	4/4
GW-1032	10.2	0.280	30.0	0/3	3.26	0.130	9.40	0/3	<0.030	ND	ND	3/3
GW-1033	<0.220	ND	ND	3/3	0.193	ND	0.570	2/3	<0.397	ND	ND	3/3
GW-1034	<0.030	ND	ND	4/4	<0.010	ND	ND	4/4	<0.030	ND	ND	4/4
GW-1035	<0.030	ND	ND	4/4	<0.010	ND	ND	4/4	<0.030	ND	ND	4/4
GW-1036	<0.030	ND	ND	5/5	<0.010	ND	ND	5/5	<0.030	ND	ND	5/5
GW-1037	<0.030	ND	ND	5/5	<0.010	ND	ND	5/5	<0.030	ND	ND	5/5
GW-1038	<0.030	ND	ND	5/5	<0.010	ND	ND	5/5	<0.030	ND	ND	5/5
GW-1039	<0.030	ND	ND	5/5	<0.010	ND	ND	5/5	<0.030	ND	ND	5/5
GW-2001	0.113	0.100	0.130	0/4	0.066	0.053	0.061	0/4	<0.030	ND	ND	4/4
GW-2002	0.067	0.051	0.078	0/4	0.410	0.250	0.510	0/4	<0.030	ND	ND	4/4

TABLE A-4 Nitroaromatic Concentrations for Groundwater, 1993 (Continued)

Location	2,4-Dinitrotoluene μg/l				2,6-Dinitrotoluene μg/l				Nitrobenzene μg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2003	0.178	0.140	0.200	0/4	0.713	0.410	1.10	0/4	<0.030	ND	ND	4/4
GW-2004	<0.030*	ND	ND	1/1	<0.010*	ND	ND	1/1	<0.030*	ND	ND	1/1
GW-2005	0.072*	0.059	0.084	0/3	0.098*	0.073	0.110	0/3	<0.030*	ND	ND	3/3
GW-2006	0.165	0.150	0.180	0/4	1.85	1.60	2.10	0/4	0.042	0.039	0.045	0/4
GW-2007	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2008	0.089	0.080	0.094	0/4	0.770	0.740	0.800	0/4	<0.030	ND	ND	4/4
GW-2009	0.067	0.057	0.076	0/4	0.190	0.120	0.250	0/4	<0.030	ND	ND	4/4
GW-2010	<0.173	ND	0.100	1/4	0.520	0.420	0.610	0/4	<0.305	ND	ND	4/4
GW-2011	0.108	0.100	0.110	0/4	1.60	1.30	1.80	0/4	<0.030	ND	0.033	1/4
GW-2012	0.100	0.087	0.120	0/4	1.08	0.720	1.40	0/4	<0.030	ND	ND	4/4
GW-2013	0.390	0.180	0.730	0/3	1.20	1.10	1.40	0/3	<0.030	ND	ND	3/3
GW-2014	0.173	0.160	0.200	0/4	0.563	0.410	0.780	0/4	<0.030	ND	ND	4/4
GW-2015	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2017	<0.030	ND	ND	4/4	<0.010	ND	ND	4/4	<0.030	ND	ND	4/4
GW-2018	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2019	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2020	0.060	0.036	0.083	0/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2021	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2022	<0.030*	ND	ND	1/1	<0.010*	ND	ND	1/1	<0.030*	ND	ND	1/1

TABLE A-4 Nitroaromatic Concentrations for Groundwater, 1993 (Continued)

Location	2,4-Dinitrotoluene μg/l				2,6-Dinitrotoluene μg/l				Nitrobenzene μg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2023	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2024	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2025	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2026	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2027	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2028	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-2029	<0.030*	ND	ND	1/1	<0.010*	ND	ND	1/1	<0.030*	ND	ND	1/1
GW-2030	0.150	0.120	0.170	0/3	4.00	3.20	5.00	0/3	<0.030	ND	ND	3/3
GW-2032	0.120	0.110	0.140	0/4	3.50	3.20	4.00	0/4	<0.030	ND	ND	4/4
GW-2033	0.178	0.100	0.280	0/4	2.29	0.720	3.20	0/4	<0.030	ND	ND	4/4
GW-2034	<0.030	ND	ND	4/4	<0.010	ND	ND	4/4	<0.030	ND	ND	4/4
GW-2035	<0.030	ND	ND	5/5	<0.010	ND	ND	5/5	<0.030	ND	ND	5/5
GW-2036	<0.086	ND	ND	5/5	<0.070	ND	ND	5/5	<0.086	ND	ND	5/5
GW-2037	0.632	0.560	0.750	0/5	0.150	0.140	0.160	0/5	<0.120	ND	0.038	4/5
GW-2038	1.68	1.50	1.80	0/5	0.320	0.280	0.350	0/5	0.070	0.063	0.077	0/5
GW-2039	<0.030	ND	ND	5/5	<0.010	ND	ND	5/5	<0.030	ND	ND	5/5
GW-2040	<0.030	ND	ND	5/5	<0.010	ND	ND	5/5	<0.030	ND	ND	5/5
GW-2041	<0.030	ND	ND	5/5	<0.010	ND	ND	5/5	0.043	ND	0.057	1/5
GW-2042	<0.030	ND	ND	5/5	<0.010	ND	ND	5/5	<0.030	ND	ND	5/5

TABLE A-4 Nitroaromatic Concentrations for Groundwater, 1993 (Continued)

Location	2,4-Dinitrotoluene µg/l				2,6-Dinitrotoluene µg/l				Nitrobenzene µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2043	0.061	0.042	0.080	0/5	<0.010	ND	ND	5/5	<0.030	ND	ND	5/5
GW-3003	<0.030	0.020	0.034	0/2	0.049	0.037	0.061	0/2	<0.030	ND	ND	2/2
GW-3006	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-3008	0.130	0.130	---	0/3	0.347	0.340	0.360	0/3	<0.030	ND	0.017	2/3
GW-3009	0.190	0.170	0.220	0/3	0.094	0.051	0.150	0/3	<0.030	ND	ND	3/3
GW-3019	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-3023	6.00	5.00	6.50	0/4	5.28	4.40	6.10	0/4	<0.030	ND	ND	4/4
GW-4001	1.43*	0.800	2.20	0/4	3.38*	3.20	3.60	0/4	<0.030*	ND	0.026	3/4
GW-4002	0.063	0.022	0.120	0/4	0.388	0.280	0.550	0/4	<0.030	ND	ND	4/4
GW-4003	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4004	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4005	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4006	<0.170	ND	0.099	1/4	2.85	2.00	3.50	0/4	<0.303	ND	ND	4/4
GW-4007	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4008	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4009	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4010	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4011	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4012	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2

TABLE A-4 Nitroaromatic Concentrations for Groundwater, 1993 (Continued)

Location	2,4-Dinitrotoluene µg/l				2,6-Dinitrotoluene µg/l				Nitrobenzene µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-4013	0.064	0.060	0.070	0/4	0.780	0.540	1.30	0/4	<0.030	ND	ND	4/4
GW-4014	<0.030	ND	ND	2/2	0.071	0.053	0.089	0/2	<0.030	ND	ND	2/2
GW-4015	0.057	0.045	0.069	0/2	0.310	0.260	0.360	0/2	<0.030	ND	ND	2/2
GW-4016	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4017	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4018	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4019	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4020	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4021	<0.030*	ND	ND	1/1	<0.010*	ND	ND	1/1	<0.030*	ND	ND	1/1
GW-4022	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-4023	0.067	0.061	0.072	0/2	0.038	0.035	0.041	0/2	<0.030	ND	ND	2/2
GW-FINW	<0.030	ND	ND	3/3	<0.010	ND	ND	3/3	<0.030	ND	ND	3/3
GW-PW02	<0.030	ND	ND	4/4	<0.010	ND	ND	4/4	<0.030	ND	ND	4/4
GW-PW03	<0.030	ND	ND	4/4	<0.010	ND	ND	4/4	<0.030	ND	ND	4/4
GW-PW04	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-PW05	<0.030	ND	ND	4/4	<0.010	ND	ND	4/4	<0.030	ND	ND	4/4
GW-PW06	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-PW07	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-PW08	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2

TABLE A-4 Nitroaromatic Concentrations for Groundwater, 1993 (Continued)

Location	2,4-Dinitrotoluene µg/l				2,6-Dinitrotoluene µg/l				Nitrobenzene µg/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-PW09	<0.030	ND	ND	4/4	<0.010	ND	ND	4/4	<0.030	ND	ND	4/4
GW-RAWW	<0.030	ND	ND	4/4	<0.010	ND	ND	4/4	<0.030	ND	ND	4/4
GW-RMW1	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-RMW2	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-RMW3	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2
GW-RMW4	<0.030	ND	ND	2/2	<0.010	ND	ND	2/2	<0.030	ND	ND	2/2

TABLE A-5 Radiological Concentrations for Groundwater, 1993

Location	Actinium-227 pCi/l				Gross Alpha pCi/l				Gross Beta pCi/l				Radium-226 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1002					<2.00	1.10	---	0/1	8.60	8.60	—	0/1	<0.300	0.300	—	0/1
GW-1004					4200	4200	—	0/1	1120	1120	—	0/1	<0.300	0.300	—	0/1
GW-1005					1220	1220	—	0/1	410	410	---	0/1	<0.300	ND	ND	0/1
GW-1006					2500	2500	---	0/1	770	770	---	0/1	0.400	0.400	—	0/1
GW-1007					680	680	—	0/1	230	230	—	0/1	0.500	0.500	—	0/1
GW-1008					2600	2600	—	0/1	1050	1050	---	0/1	<0.300	ND	ND	0/1
GW-1009					14.0	14.0	—	0/1	7.90	7.90	—	0/1	1.20	1.20	—	0/1
GW-1010					<2.000	ND	ND	0/1	7.80	7.80	—	0/1	<0.300	0.300	---	0/1
GW-1011					7.30	7.30	—	0/1	15.0	15.0	—	0/1	<0.300	ND	ND	0/1
GW-1012					27.0	27.0	—	0/1	15.0	15.0	---	0/1	0.500	0.500	—	0/1
GW-1013					510	510	---	0/1	220	220	—	0/1	0.900	0.900	---	0/1
GW-1014					610	610	—	0/1	260	260	—	0/1	<0.300	0.100	—	0/1
GW-1015					690	690	---	0/1	200	200	—	0/1	1.30	1.30	---	0/1
GW-1016					270	270	---	0/1	120	120	—	0/1	0.600	0.600	—	0/1
GW-1017					<2.00	2.00	—	0/1	13.0	13.0	---	0/1	0.700	0.700	—	0/1
GW-1018					5.90	5.90	---	0/1	9.60	9.60	—	0/1	0.500	0.500	—	0/1
GW-1019					46.0	46.0	—	0/1	13.0	13.0	—	0/1	0.600	0.600	---	0/1
GW-1020					2.20	2.20	—	0/1	<4.00	3.90	—	0/1	0.400	0.400	---	0/1
GW-1021					6.50	6.50	—	0/1	7.10	7.10	—	0/1	0.400	0.400	---	0/1

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Actinium-227 pCi/l				Gross Alpha pCi/l				Gross Beta pCi/l				Radium-226 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1022					3.40	3.40	---	0/1	7.30	7.30	---	0/1	1.60	1.60	---	0/1
GW-1023					<2.000	ND	1.30	0/2	7.00	4.10	9.90	0/2	<0.300	0.100	---	0/1
GW-1024					<2.00	ND	3.90	0/2	11.0	10.0	12.0	0/2	0.700	0.700	---	0/1
GW-1025	<25.0	ND	ND	1/1	7.00	7.00	---	0/1	6.50	6.50	---	0/1	0.600	0.600	---	0/1
GW-1027	<25.0	ND	ND	1/1	630	630	---	0/1	180	180	---	0/1	<0.300	ND	ND	1/1
GW-1028					<7.53	2.69	---	0/1	<5.17	4.86	---	0/1	<0.769	0.350	---	0/1
GW-1029					4.60	4.60	---	0/1	7.20	7.20	---	0/1	<0.300	ND	ND	0/1
GW-1030					6.40	6.40	---	0/1	15.0	15.0	---	0/1	<0.300	ND	ND	0/1
GW-1031					18.0	18.0	---	0/1	8.70	8.70	---	0/1	<0.300	ND	ND	0/1
GW-1032					910	910	---	0/1	350	350	---	0/1	<0.300	ND	ND	0/1
GW-1033					<2.000	0.600	---	0/1	9.00	9.00	---	0/1	<0.300	ND	ND	0/1
GW-1034					10.4	10.4	---	0/1	6.73	6.73	---	0/1	<0.748	0.200	---	0/1
GW-1035													<0.300	0.300	---	0/1
GW-1036	<25.0	ND	ND	1/1	9.40	9.40	---	0/1	12.0	12.0	---	0/1	<0.300	ND	ND	1/1
GW-1037					<2.000	ND	ND	0/1	5.50	5.50	---	0/1	0.400	0.400	---	0/1
GW-1038					7.80	7.80	---	0/1	6.80	6.80	---	0/1	<0.300	0.100	---	0/1
GW-1039					3.10	3.10	---	0/1	<4.00	3.00	---	0/1	<0.300	ND	ND	0/1
GW-2001					<7.23	1.72	---	0/1	5.94	5.94	---	0/1	<0.764	0.200	---	0/1
GW-2002					<20.5	19.5	---	0/1	23.0	23.0	---	0/1	<0.767	0.600	---	0/1

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Actinium-227 pCi/l				Gross Alpha pCi/l				Gross Beta pCi/l				Radium-226 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2003					<29.8	ND	ND	1/1	27.8	27.8	---	0/1	<0.800	0.100	—	0/1
GW-2004																
GW-2005																
GW-2006																
GW-2007																
GW-2008																
GW-2009																
GW-2010																
GW-2011																
GW-2012																
GW-2013																
GW-2014																
GW-2015					<2.00	1.30	---	0/1	4.10	4.10	---	0/1	<0.300	ND	ND	0/1
GW-2017																
GW-2018					<2.000	ND	ND	0/1	4.30	4.30	—	0/1	1.30	1.30	—	0/1
GW-2019																
GW-2020					6.70	6.70	---	0/1	4.80	4.80	—	0/1	<0.300	ND	ND	0/1
GW-2021					2.10	2.10	---	0/1	<4.00	3.00	—	0/1	<0.300	ND	ND	0/1
GW-2022					2.10	2.10	—	0/1	<4.00	3.50	---	0/1	<0.300	ND	ND	0/1

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Actinium-227 pCi/l				Gross Alpha pCi/l				Gross Beta pCi/l				Radium-226 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2023																
GW-2024																
GW-2025																
GW-2026																
GW-2027																
GW-2028					<2.000	0.700	---	0/1	<4.00	3.20	---	0/1	<0.300	ND	ND	0/1
GW-2029																
GW-2030																
GW-2032																
GW-2033																
GW-2034																
GW-2035					<2.00	1.30	---	0/1	<4.00	1.40	---	0/1	<0.300	0.100	---	0/1
GW-2036					<2.00	1.20	---	0/1	<4.000	0.100	---	0/1	<0.300	0.100	---	0/1
GW-2037					<2.00	ND	ND	1/1	18.0	18.0	---	0/1	<0.300	ND	ND	1/1
GW-2038																
GW-2039					5.40	5.40	---	0/1	6.90	6.90	---	0/1	<0.300	ND	ND	1/1
GW-2040					<2.00	1.70	---	0/1	5.40	5.40	---	0/1	<0.300	0.300	---	0/1
GW-2041					<2.00	ND	ND	1/1	<4.00	4.00	---	0/1	0.600	0.600	---	0/1
GW-2042					<2.00	ND	ND	1/1	<4.00	1.70	---	0/1	0.500	0.500	---	0/1

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Actinium-227 pCi/l				Gross Alpha pCi/l				Gross Beta pCi/l				Radium-226 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2043					<2.00	ND	ND	1/1	<4.00	ND	ND	1/1	<0.300	ND	ND	1/1
GW-3003					15.0	15.0	---	0/1	36.0	36.0	---	0/1	<0.300	0.100	---	0/1
GW-3006					<2.00	ND	ND	1/1	<4.00	1.80	---	0/1	0.500	0.500	---	0/1
GW-3008					<2.00	ND	ND	1/1	70.0	70.0	---	0/1	1.00	1.00	---	0/1
GW-3009					80.0	80.0	---	0/1	32.0	32.0	---	0/1	4.90	4.90	---	0/1
GW-3019					<2.000	0.300	---	0/1	<4.00	3.30	---	0/1	0.600	0.600	---	0/1
GW-3023					3.00	3.00	---	0/1	33.0	33.0	---	0/1	<0.300	ND	ND	0/1
GW-4001																
GW-4002																
GW-4003																
GW-4004																
GW-4005																
GW-4006																
GW-4007																
GW-4008																
GW-4009																
GW-4010					<2.000	0.500	---	0/1	<4.00	1.20	---	0/1	<0.300	0.200	---	0/1
GW-4011					8.20	8.20	---	0/1	14.0	14.0	---	0/1	<0.300	0.100	---	0/1
GW-4012																

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Actinium-227 pCi/l				Gross Alpha pCi/l				Gross Beta pCi/l				Radium-226 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-4013																
GW-4014																
GW-4015																
GW-4016																
GW-4017																
GW-4018																
GW-4019																
GW-4020																
GW-4021																
GW-4022																
GW-4023																
GW-FINW					<1.720	ND	0.700	2/4	4.63	3.20	5.70	0/3	0.800	0.800	---	0/1
GW-PW02					<1.94	ND	2.60	1/4	4.70	3.80	5.50	0/3	0.400	0.400	---	0/1
GW-PW03					<1.80	ND	3.30	1/4	7.13	5.90	8.20	0/3	0.400	0.400	—	0/1
GW-PW04					2.95	ND	4.90	1/2	<4.00	2.30	5.70	0/2	0.700	0.700	---	0/1
GW-PW05					2.56	ND	7.10	0/4	6.57	4.10	10.0	0/3	0.800	0.800	—	0/1
GW-PW06					<2.000	ND	ND	1/2	4.60	4.20	5.00	0/2	<0.300	0.300	—	0/1
GW-PW07					5.10	ND	9.20	1/2	6.60	3.20	10.0	0/2	0.500	0.500	--	0/1
GW-PW08					2.20	ND	3.40	1/2	<4.00	2.40	4.80	0/2	0.900	0.900	---	0/1

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Actinium-227 pCi/l				Gross Alpha pCi/l				Gross Beta pCi/l				Radium-226 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-PW09					2.77	ND	5.30	1/4	6.00	4.60	8.80	0/3	<0.300	0.100	—	0/1
GW-RAWW					<2.03	ND	4.17	1/4	4.73	3.50	5.60	0/3	0.600	0.600	—	0/1
GW-RMW1					<2.00	ND	2.60	0/2	6.65	6.30	7.00	0/2	2.80	2.80	—	0/1
GW-RMW2					2.40	0.400	4.40	0/2	5.00	4.50	5.50	0/2	0.700	0.700	—	0/1
GW-RMW3					<2.00	1.40	2.20	0/2	10.5	8.90	12.0	0/2	0.500	0.500	—	0/1
GW-RMW4					<2.00	ND	2.10	0/2	<4.00	1.80	4.10	0/2	<0.300	ND	ND	0/1

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Radium-226 pCi/l				Thorium-228 pCi/l				Thorium-230 pCi/l				Thorium-232 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1002	<1.000	0.500	---	0/1	<0.400	ND	ND	0/1	<0.400	0.100	---	0/1	<0.400	ND	ND	0/1
GW-1004	<1.000	0.600	---	0/1	0.600	0.500	---	0/1	1.30	1.30	---	0/1	<0.400	0.100	---	0/1
GW-1005	<1.000	0.700	---	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-1006	<1.000	0.700	---	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-1007	<1.000	0.200	---	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-1008	<1.000	0.100	—	0/1	<0.400	ND	ND	0/1	<0.400	0.200	---	0/1	<0.400	ND	ND	0/1
GW-1009	<1.000	ND	ND	0/1	<0.400	ND	ND	0/1	0.700	0.700	—	0/1	<0.400	ND	ND	0/1
GW-1010	<1.000	0.100	—	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-1011	<1.000	0.100	—	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-1012	<1.000	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-1013	<1.000	0.400	---	0/1	<0.400	ND	ND	0/1	0.600	0.600	---	0/1	<0.400	ND	ND	0/1
GW-1014	<1.000	0.300	—	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-1015	<1.000	0.600	---	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-1016	<1.000	0.400	---	0/1	<0.400	ND	ND	0/1	1.60	1.60	---	0/1	<0.400	ND	ND	0/1
GW-1017	1.60	1.60	—	0/1	<0.400	ND	ND	0/1	0.600	0.600	---	0/1	<0.400	ND	ND	0/1
GW-1018	<1.000	0.300	---	0/1	<0.400	ND	ND	0/1	0.800	0.800	---	0/1	<0.400	ND	ND	0/1
GW-1019	1.90	1.90	—	0/1	<0.400	ND	ND	0/1	0.800	0.800	—	0/1	<0.400	ND	ND	0/1
GW-1020	<1.000	0.400	—	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-1021	2.10	2.10	—	0/1	<0.400	0.100	---	0/1	<0.400	0.400	—	0/1	<0.400	ND	ND	0/1

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Radium-228 pCi/l				Thorium-228 pCi/l				Thorium-230 pCi/l				Thorium-232 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1022	<1.000	0.400	---	0/1	<0.400	ND	ND	0/1	0.500	0.500	---	0/1	<0.400	0.300	---	0/1
GW-1023	<1.00	1.00	---	0/1	<0.400	ND	ND	0/1	2.00	2.00	---	0/1	<0.400	ND	ND	0/1
GW-1024	<1.000	ND	ND	0/1	<0.400	ND	ND	0/1	0.800	0.800	---	0/1	<0.400	0.100	---	0/1
GW-1026	<1.000	0.600	---	0/1	<0.400	ND	ND	1/1	<0.400	ND	ND	1/1	<0.400	ND	ND	1/1
GW-1027	<1.000	ND	ND	1/1	<0.400	ND	ND	1/1	<0.400	ND	ND	1/1	<0.400	ND	ND	1/1
GW-1028	<1.220	0.450	---	0/1	<0.950	0.130	---	0/1	<0.950	0.220	---	0/1	<0.950	ND	ND	1/1
GW-1029	<1.000	0.900	---	0/1	<0.400	ND	ND	0/1	0.500	0.500	---	0/1	<0.400	ND	ND	0/1
GW-1030	<1.000	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-1031	<1.000	0.800	---	0/1	<0.400	ND	ND	0/1	<0.400	0.300	---	0/1	<0.400	ND	ND	0/1
GW-1032	<1.000	0.200	---	0/1	<0.400	ND	ND	0/1	1.80	1.80	---	0/1	<0.400	ND	ND	0/1
GW-1033	<1.000	0.700	---	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-1034	<1.220	ND	ND	1/1	<0.950	ND	ND	1/1	<0.950	ND	ND	1/1	<0.950	ND	ND	1/1
GW-1035	<1.000	0.600	---	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-1036	<1.000	ND	ND	1/1	<0.400	ND	ND	1/1	<0.400	ND	ND	1/1	<0.400	ND	ND	1/1
GW-1037	<1.000	0.800	---	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-1038	<1.000	0.500	---	0/1	<0.400	ND	ND	0/1	<0.400	0.200	---	0/1	<0.400	ND	ND	0/1
GW-1039	2.40	2.40	---	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-2001	<1.370	0.110	---	0/1	<0.950	ND	ND	1/1	<0.950	ND	ND	1/1	<0.950	ND	ND	1/1
GW-2002	<1.200	ND	ND	1/1	<0.950	ND	ND	1/1	<0.950	ND	ND	1/1	<0.950	ND	ND	1/1

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Radium-228 pCi/l				Thorium-228 pCi/l				Thorium-230 pCi/l				Thorium-232 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2003	<1.200	0.120	—	0/1	<0.950	ND	ND	1/1	<0.950	ND	ND	1/1	<0.950	ND	ND	1/1
GW-2004																
GW-2005																
GW-2006																
GW-2007																
GW-2008																
GW-2009																
GW-2010																
GW-2011																
GW-2012																
GW-2013																
GW-2014																
GW-2015	<1.000	0.300	—	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-2017																
GW-2018	<1.000	0.500	—	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-2019																
GW-2020	<1.000	ND	ND	0/1	<0.400	ND	ND	0/1	1.80	1.80	—	0/1	<0.400	ND	ND	0/1
GW-2021	<1.000	0.100	—	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-2022	1.20	1.20	—	0/1	<0.400	ND	ND	0/1	1.20	1.20	—	0/1	<0.400	ND	ND	0/1

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Radium-228 pCi/l				Thorium-228 pCi/l				Thorium-230 pCi/l				Thorium-232 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2023																
GW-2024																
GW-2025																
GW-2026																
GW-2027																
GW-2028	<1.000	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-2029																
GW-2030																
GW-2032																
GW-2033																
GW-2034																
GW-2035	<1.000	0.300	---	0/1	<0.400	ND	ND	1/1	3.50	3.50	---	0/1	<0.400	ND	ND	1/1
GW-2036	<1.000	0.200	---	0/1	<0.400	ND	ND	1/1	<0.400	0.200	---	0/1	<0.400	ND	ND	1/1
GW-2037	<1.000	0.600	---	0/1	<0.400	ND	ND	1/1	<0.400	0.100	---	0/1	<0.400	ND	ND	1/1
GW-2038																
GW-2039	<1.000	0.400	---	0/1	<0.400	ND	ND	1/1	<0.400	ND	ND	1/1	<0.400	ND	ND	1/1
GW-2040	<1.000	0.500	---	0/1	<0.400	ND	ND	1/1	<0.400	0.100	---	0/1	<0.400	ND	ND	1/1
GW-2041	<1.000	0.700	---	0/1	<0.400	ND	ND	1/1	0.500	0.500	---	0/1	<0.400	ND	ND	1/1
GW-2042	<1.000	ND	ND	1/1	<0.400	0.100	---	0/1	<0.400	0.300	---	0/1	<0.400	ND	ND	1/1

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Radium-228 pCi/l				Thorium-228 pCi/l				Thorium-230 pCi/l				Thorium-232 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2043	<1.000	ND	ND	1/1	<0.400	ND	ND	1/1	0.700	0.700	---	0/1	<0.400	0.400	---	0/1
GW-3003	<1.00	1.00	---	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-3006	<1.000	ND	ND	1/1	<0.400	ND	ND	1/1	<0.400	0.300	—	0/1	<0.400	0.200	---	0/1
GW-3008	<1.000	ND	ND	1/1	<0.400	ND	ND	1/1	<0.400	ND	ND	1/1	<0.400	ND	ND	1/1
GW-3009	<1.000	0.500	---	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-3019	1.10	1.10	---	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-3023	<1.000	ND	ND	0/1	0.800	0.800	—	0/1	0.900	0.900	—	0/1	<0.400	0.100	—	0/1
GW-4001																
GW-4002																
GW-4003																
GW-4004																
GW-4005																
GW-4006																
GW-4007																
GW-4008																
GW-4009																
GW-4010	<1.000	0.200	---	0/1	<0.400	ND	ND	1/1	<0.400	0.100	---	0/1	<0.400	ND	ND	1/1
GW-4011	<1.000	0.100	—	0/1	<0.400	ND	ND	1/1	0.900	0.900	---	0/1	<0.400	ND	ND	1/1
GW-4012																

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Radium-228 pCi/l				Thorium-228 pCi/l				Thorium-230 pCi/l				Thorium-232 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-4013																
GW-4014																
GW-4015																
GW-4016																
GW-4017																
GW-4018																
GW-4019																
GW-4020																
GW-4021																
GW-4022																
GW-4023																
GW-FINW	<1.000	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	0.100	—	0/1	<0.400	ND	ND	0/1
GW-PW02	<1.000	ND	ND	0/1	<0.400	0.100	---	0/1	0.600	0.600	—	0/1	<0.400	ND	ND	0/1
GW-PW03	<1.000	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-PW04	<1.000	0.700	---	0/1	<0.400	ND	ND	0/1	<0.400	0.100	---	0/1	<0.400	ND	ND	0/1
GW-PW05	<1.000	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-PW06	<1.000	ND	ND	0/1	<0.400	ND	ND	0/1	4.50	4.50	---	0/1	<0.400	ND	ND	0/1
GW-PW07	1.50	1.50	---	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-PW08	1.30	1.30	---	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Radium-228 pCi/l				Thorium-228 pCi/l				Thorium-230 pCi/l				Thorium-232 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-PW09	<1.00	1.00	--	0/1	<0.400	ND	ND	0/1	<0.400	0.400	—	0/1	<0.400	ND	ND	0/1
GW-RAWW	<1.000	0.200	—	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-RMW1	<1.000	0.200	—	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-RMW2	<1.000	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-RMW3	<1.000	0.600	--	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	0.200	--	0/1
GW-RMW4	<1.000	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	0.100	—	0/1	<0.400	ND	ND	0/1

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Uranium, Total pCi/l				Uranium-234 pCi/l				Uranium-235 pCi/l				Uranium-238 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1002	2.66	2.00	3.50	0/10												
GW-1004	4503	2200	8600	0/12												
GW-1005	1526	1300	2200	0/12												
GW-1006	2788	2400	3300	0/4												
GW-1007	338	50.0	680	0/4												
GW-1008	3063	2650	3300	0/4												
GW-1009	8.77	5.40	14.0	0/3												
GW-1010	0.300	ND	0.500	1/4												
GW-1011	7.50	3.30	13.0	0/4												
GW-1012	3.33	2.70	4.20	0/6	2.90	2.90	---	0/1	<0.400	ND	ND	0/1	1.20	1.20	---	0/1
GW-1013	633	470	780	0/4												
GW-1014	770	560	1000	0/4												
GW-1015	615	220	920	0/6												
GW-1016	347	230	520	0/6												
GW-1017	<0.200	ND	ND	2/2												
GW-1018	0.300	ND	0.700	2/3												
GW-1019	<0.200	ND	0.400	2/3												
GW-1020	1.53	ND	3.80	1/3												
GW-1021	<0.200	ND	ND	2/2												

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Uranium, Total pCi/l				Uranium-234 pCi/l				Uranium-235 pCi/l				Uranium-238 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-1022	0.467	ND	1.20	2/3												
GW-1023	<0.200	ND	ND	2/2												
GW-1024	<0.200	ND	ND	2/2												
GW-1026	0.283	ND	0.500	1/6												
GW-1027	532	5.00	820	0/12												
GW-1028	1.47	1.30	1.60	0/3												
GW-1029	2.26	2.10	2.70	0/7												
GW-1030	322	5.60	990	0/9												
GW-1031	21.5	19.0	25.0	0/4												
GW-1032	1097	930	1260	0/3												
GW-1033	1.95	1.80	2.10	0/2												
GW-1034	1.65	ND	2.10	1/5												
GW-1035	1.25	ND	2.40	1/4												
GW-1036	6.10	4.10	8.00	0/4												
GW-1037	1.18	0.600	2.20	0/4	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1
GW-1038	3.75	3.30	4.60	0/4	1.70	1.70	---	0/1	<0.400	ND	ND	0/1	1.40	1.40	---	0/1
GW-1039	0.625	0.400	0.800	0/4	0.700	0.700	---	0/1	<0.400	ND	ND	0/1	0.600	0.600	---	0/1
GW-2001	0.950	ND	0.900	1/3												
GW-2002	2.13	0.500	5.20	0/3												

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Uranium, Total pCi/l				Uranium-234 pCi/l				Uranium-235 pCi/l				Uranium-238 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2003	1.98	1.30	2.60	0/4												
GW-2004	0.800	0.700	1.00	0/4												
GW-2005	0.625	0.500	0.800	0/4												
GW-2006	0.725	0.500	1.00	0/4												
GW-2007	1.07	0.900	1.30	0/3												
GW-2008	0.825	0.500	1.30	0/4												
GW-2009	2.00	1.80	2.40	0/3												
GW-2010	1.10	0.800	1.40	0/4												
GW-2011	0.600	0.500	0.700	0/4												
GW-2012	0.825	0.700	1.00	0/4												
GW-2013	0.900	0.700	1.00	0/4												
GW-2014	0.800	0.500	1.10	0/4												
GW-2015	1.78	1.50	1.90	0/4												
GW-2017	9.28	8.80	10.0	0/4												
GW-2018	1.70	1.60	2.00	0/4												
GW-2019	2.53	1.80	3.00	0/4												
GW-2020	1.97	1.70	2.20	0/3												
GW-2021	1.25	1.00	1.60	0/4												
GW-2022	0.550	ND	0.900	1/4												

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Uranium, Total pCi/l				Uranium-234 pCi/l				Uranium-235 pCi/l				Uranium-238 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2023	2.35	2.10	2.60	0/4												
GW-2024	<0.200	ND	0.200	2/4												
GW-2025	0.975	0.600	1.40	0/4												
GW-2026	1.28	0.800	2.10	0/4												
GW-2027	0.750	0.400	0.900	0/4												
GW-2028	1.28	1.00	1.60	0/4												
GW-2029	2.08	1.80	2.50	0/4												
GW-2030	9.60	8.80	11.0	0/4												
GW-2032	3.53	3.30	3.80	0/4												
GW-2033	0.800	0.500	1.00	0/4												
GW-2034	5.28	4.40	7.30	0/4												
GW-2035	0.740	ND	1.40	1/5												
GW-2036	0.980	0.700	1.40	0/5												
GW-2037	1.20	1.00	1.40	0/5												
GW-2038	1.42	1.20	1.60	0/5												
GW-2039	2.88	2.70	3.10	0/5												
GW-2040	2.10	1.60	2.60	0/5												
GW-2041	5.54	4.70	6.90	0/5												
GW-2042	2.34	2.10	2.60	0/5												

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Uranium, Total pCi/l				Uranium-234 pCi/l				Uranium-235 pCi/l				Uranium-238 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-2043	1.70	1.50	2.00	0/6												
GW-3003	19.3	14.0	24.0	0/4												
GW-3006	0.550	0.200	0.900	0/2												
GW-3008	3.13	3.10	3.20	0/3												
GW-3009	28.0	1.10	54.0	0/3												
GW-3019	2.15	1.80	2.50	0/4												
GW-3023	8.53	8.30	8.80	0/4												
GW-4001	0.500	0.500	--	0/2												
GW-4002	1.00	1.00	--	0/2												
GW-4003	1.10	1.00	1.20	0/2												
GW-4004	1.95	1.20	2.70	0/2												
GW-4005	1.43	1.20	1.70	0/4												
GW-4006	0.600	0.500	0.700	0/2												
GW-4007	1.75	1.70	1.80	0/2												
GW-4008	1.30	1.00	1.60	0/2												
GW-4009	2.60	1.80	3.40	0/2												
GW-4010	3.25	2.90	3.60	0/2												
GW-4011	5.15	4.70	5.60	0/2												
GW-4012	2.90	2.30	3.50	0/2												

052094

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Uranium, Total pCi/l				Uranium-234 pCi/l				Uranium-235 pCi/l				Uranium-238 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-4013	0.850	0.700	1.00	0/2												
GW-4014	<0.200	ND	ND	2/2												
GW-4015	0.550	0.500	0.600	0/2												
GW-4016	3.20	2.90	3.50	0/2												
GW-4017	1.15	0.700	1.60	0/2												
GW-4018	0.400	ND	0.700	1/2												
GW-4019	1.45	1.40	1.50	0/2												
GW-4020	13.2	9.70	16.0	0/4												
GW-4021	3.20*	2.70	3.60	0/3												
GW-4022	4.93	3.60	6.10	0/4												
GW-4023	0.650	0.300	1.00	0/2												
GW-FINW	<0.543	ND	1.20	3/7												
GW-PW02	<0.520	ND	0.300	3/5												
GW-PW03	<0.520	ND	0.500	3/5												
GW-PW04	<0.200	ND	ND	2/2												
GW-PW05	<0.520	ND	0.600	3/5												
GW-PW06	<0.200	ND	ND	2/2												
GW-PW07	<0.200	ND	ND	2/2												
GW-PW08	<0.200	ND	0.300	1/2												

TABLE A-5 Radiological Concentrations for Groundwater, 1993 (Continued)

Location	Uranium, Total pCi/l				Uranium-234 pCi/l				Uranium-235 pCi/l				Uranium-238 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
GW-PW09	<0.520	ND	0.300	3/5												
GW-RAWW	<0.543	ND	0.400	1/7												
GW-RMW1	0.700	0.400	1.00	0/2												
GW-RMW2	5.20	4.40	6.00	0/2												
GW-RMW3	0.750	ND	1.40	1/2												
GW-RMW4	1.05	0.900	1.20	0/2												

Table A-6 Anion Concentrations for Groundwater, 1993

	Bromide mg/l				Chloride mg/l				Fluoride mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
NP-0001												
NP-0002												
NP-0003												
NP-0004												
NP-0005												
NP-EPQ1	<0.100	ND	ND	1/1	65.8	23.5	226	0/20	<0.105	ND	ND	20/20
NP-EPQ2					163	21.7	232	0/7	<0.314	ND	0.704	6/7
NP-EPS1					89.8	50.3	166	0/7	1.04	0.480	1.90	0/7
NP-EPS2					107	72.3	309	0/23	0.545	ND	2.50	3/23
NP-TSAB												

Table A-6 Anion Concentrations for Groundwater, 1993 (Continued)

	Nitrate-N mg/l				Nitrite-N mg/l				Sulfate mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
NP-0001	0.261	ND	0.720	2/4								
NP-0002	0.642	ND	1.60	1/12								
NP-0003	2.23	ND	13.0	1/12								
NP-0004	0.320	0.074	0.530	0/4								
NP-0005	0.210	ND	0.660	1/12								
NP-EPQ1	0.117	ND	0.586	15/20	<0.010	ND	ND	1/1	141	44.1	256	0/7
NP-EPQ2	0.100	ND	0.550	6/7					159	51.8	302	0/7
NP-EPS1	1.34	0.490	2.83	0/7					166	106	248	0/7
NP-EPS2	1.57	ND	7.96	1/23					154	115	236	0/11
NP-TSAB	1.87	0.267	8.00	0/9								

TABLE A-7 Metal Concentrations for NPDES, 1993

	Arsenic µg/l				Barium µg/l				Boron µg/l				Cadmium µg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
NP-0001																
NP-0002	<2.00	ND	ND	1/1												
NP-0003	<2.00	ND	ND	1/1												
NP-0004																
NP-0005																
NP-EPQ1	<1.360	ND	ND	20/20	21.3	ND	44.1	1/7	119	119	—	0/1	<3.60	ND	0.530	5/7
NP-EPQ2	<1.571	ND	ND	7/7	23.9	10.0	34.2	0/7					<3.44	ND	0.140	6/7
NP-EPS1	1.87	ND	4.70	5/7	16.3	5.20	26.4	0/7					<3.17	ND	0.150	6/7
NP-EPS2	<1.80	ND	7.90	20/23	15.2	6.80	25.6	0/11					<3.39	ND	5.00	7/11
NP-TSAB	<2.00	ND	ND	1/1												

TABLE A-7 Metal Concentrations for NPDES, 1993 (Continued)

	Chromium µg/l				Copper µg/l				Iron µg/l				Lead µg/l		
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max
NP-0001															
NP-0002															
NP-0003															
NP-0004															
NP-0005															
NP-EPQ1	<5.67	ND	ND	7/7	<7.86	ND	ND	7/7	<39.8	ND	67.2	1/7	<6.87	ND	7.93
NP-EPQ2	<4.67	ND	6.00	3/7	6.93	ND	16.0	4/7	38.3	ND	93.0	1/7	3.66	ND	14.0
NP-EPS1	<4.67	ND	6.70	6/7	<5.57	ND	9.00	5/7	53.2	42.4	91.0	0/7	<1.100	ND	ND
NP-EPS2	<5.49	ND	3.60	10/11	<7.24	ND	4.40	10/11	69.3	ND	194	1/11	<4.97	ND	2.37
NP-TSAB	<5.00	ND	ND	1/1	<6.00	ND	ND	1/1							

TABLE A-8 Miscellaneous Parameter Concentrations for NPDES, 1993

	Ammonia mg/l				Asbestos MAS/L				Biochemical Oxygen Demand mg/l				Chemical Oxygen Demand mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
NP-0001																
NP-0002																
NP-0003																
NP-0004																
NP-0005																
NP-0006																
NP-EPQ1	<0.030	ND	ND	1/1	<0.184	ND	ND	7/7	<1.71	ND	2.00	5/7	<5.00	ND	9.00	15/20
NP-EPQ2					<0.183	ND	ND	7/7	<1.57	ND	2.10	4/7	7.43	ND	21.0	3/7
NP-EPS1					<0.177	ND	ND	7/7	<1.71	ND	3.30	6/7	<5.00	ND	8.00	4/7
NP-EPS2					<0.175	ND	ND	10/10	2.19	ND	12.5	7/11	<5.00	ND	16.8	20/23
NP-TSAB																

TABLE A-8 Miscellaneous Parameter Concentrations for NPDES, 1993 (Continued)

	Cyanide UG/L				Nitrogen, Total Kjeldahl mg/l				Oil & Grease mg/l				Phosphorous mg/l		
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max
NP-0001															
NP-0002															
NP-0003															
NP-0004															
NP-0005															
NP-0006															
NP-EPQ1	<7.14	ND	ND	7/7	0.199	0.199	---	0/1	50.7	ND	147	2/3	0.423	0.423	---
NP-EPQ2	<5.00	ND	ND	7/7					<5.00	ND	ND	1/1			
NP-EPS1	<5.00	ND	ND	7/7					<5.00	ND	ND	2/2			
NP-EPS2	<5.00	ND	ND	11/11					<5.00	ND	ND	3/3			
NP-TSAB									<5.00	ND	ND	3/3			

TABLE A-9 Nitroaromatic Concentrations for NPDES, 1993

	2,4,6-Trinitrotoluene μg/l				2,4-Dinitrotoluene μg/l				
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	
NP-EPQ1	<0.260	ND	ND	7/7	<0.019	ND	ND	20/20	
NP-EPQ2	<0.260	ND	ND	7/7	<0.019	ND	ND	7/7	
NP-EPS1	<0.260	ND	ND	7/7	<0.019	ND	ND	7/7	
NP-EPS2	<2.83	ND	ND	10/10	<0.882	ND	ND	22/22	

TABLE A-10 Radiological Concentrations for NPDES, 1993

Location	Actinium-227 pCi/l				Gross Alpha pCi/l				Gross Beta pCi/l				Polonium-210 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
NP-0001					1080*	590	1630	0/5	186*	113	300	0/5				
NP-0002					265*	61.0	727	0/12	56.3*	28.0	128	0/12				
NP-0003					683	125	1250	0/13	185	32.9	544	0/13				
NP-0004					13.4*	10.8	17.5	0/3	6.22*	3.13	8.34	0/3				
NP-0005					344	6.30	2820	0/12	60.3	5.60	258	0/12				
NP-EPQ1					5.21	ND	12.0	1/7	8.34	5.70	11.0	0/7				
NP-EPQ2	<9.30	ND	ND	1/1	2.79	ND	6.50	1/7	7.51	3.90	14.0	0/7	<1.000	0.300	---	0/1
NP-EPS1					2.46	1.10	4.00	0/7	7.52	5.30	14.0	0/7				
NP-EPS2					2.87	ND	5.00	1/10	7.82	4.45	12.0	0/10				
NP-TSAB					2.15	ND	3.90	1/9	4.79	ND	11.0	1/9				

TABLE A-10 Radiological Concentrations for NPDES, 1993 (Continued)

Location	Radium-226 pCi/l				Radium-228 pCi/l				Radon-222 pCi/l				Thorium-228 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
NP-0001																
NP-0002																
NP-0003																
NP-0004																
NP-0005																
NP-EPQ1	<0.346	ND	0.680	2/7	<0.917	ND	0.600	2/7					<0.386	ND	1.30	3/7
NP-EPQ2	<0.300	ND	0.200	2/7	<1.000	ND	0.500	3/7	<150.0	ND	ND	1/1	<0.400	ND	ND	7/7
NP-EPS1	0.583	0.100	0.980	0/7	<0.951	ND	1.10	2/7					<0.369	ND	0.140	6/7
NP-EPS2	0.465	ND	1.80	3/10	<0.989	ND	1.20	2/10					<0.377	ND	0.160	8/10
NP-TSAB																

TABLE A-10 Radiological Concentrations for NPDES, 1993 (Continued)

Location	Thorium-230 pCi/l				Thorium-232 pCi/l				Uranium, Total pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
NP-0001									980*	530	1360	0/5
NP-0002									259*	76.0	847	0/12
NP-0003									689	126	1540	0/13
NP-0004									8.80*	7.34	11.0	0/3
NP-0005									267	7.62	1900	0/12
NP-EPQ1	0.694	ND	3.14	3/7	<0.386	ND	0.060	4/7	0.845	ND	8.40	14/20
NP-EPQ2	<0.400	ND	0.900	1/7	<0.400	ND	ND	7/7	1.91	ND	6.40	2/7
NP-EPS1	<0.376	ND	0.300	1/7	<0.374	ND	0.400	5/7	0.630	0.300	1.40	0/7
NP-EPS2	0.689	ND	3.30	2/10	<0.371	ND	ND	9/10	<0.353	ND	1.00	4/22
NP-TSAB									1.76	0.246	7.40	0/9

TABLE A-11 Uranium Concentrations in Sediment for NPDES, 1993

	Uranium, Total pCi/g			
Location	Avg	Min	Max	Ratio
SD-4090	1.15	0.700	1.60	0/2
SD-4091	1.55	1.50	1.60	0/2

TABLE A-12 Anion Concentrations for Springs, 1993

	Bromide mg/l				Chloride mg/l				Nitrate-N mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SP-5201	<0.380	ND	ND	2/2	6.45	5.70	7.20	0/2	0.153	0.100	0.200	0/3
SP-5303	<0.380	ND	ND	2/2	8.90	4.60	13.2	0/2	0.857	0.200	2.00	0/3
SP-5304	<0.380	ND	ND	2/2	4.30	3.10	5.50	0/2	0.687	0.590	0.750	0/3
SP-6301	<0.380	ND	ND	4/4	6.40	4.60	7.70	0/4	5.04	0.530	12.1	0/6
SP-6306	<0.380	ND	ND	4/4	9.32	7.79	11.0	0/4	2.29	ND	11.3	1/6

	Nitrite-N mg/l				Sulfate mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SP-5201	<0.055	ND	ND	2/2	31.0	23.9	35.8	0/3
SP-5303	<0.055	ND	ND	2/2	37.8	33.7	41.7	0/3
SP-5304	<0.055	ND	ND	2/2	31.0	26.8	34.0	0/3
SP-6301	<0.070	ND	ND	3/3	24.7	12.2	31.2	0/6
SP-6306	<0.088	ND	ND	4/4	14.9	6.00	26.2	0/6

TABLE A-13 Metal Concentrations for Springs, 1993

	Aluminum µg/l				Antimony µg/l				Arsenic µg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SP-5201	<31.0	ND	15.6	1/2	<33.0	ND	ND	2/2	<2.00	ND	ND	2/2
SP-5303	57.3	ND	90.5	1/2	<33.0	ND	ND	2/2	<2.00	ND	ND	2/2
SP-5304	<31.0	ND	29.2	1/2	<33.0	ND	ND	2/2	<2.00	ND	ND	2/2
SP-6301	<46.8	ND	ND	4/4	<46.3	ND	ND	3/3	<2.00	ND	ND	4/4
SP-6306	<29.8	ND	50.6	2/4	<36.0	ND	ND	4/4	4.02	ND	10.2	2/4

	Barium µg/l				Beryllium µg/l				Cadmium µg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SP-5201	109	106	112	0/2	<1.000	ND	ND	2/2	<3.50	ND	ND	2/2
SP-5303	122	111	132	0/2	<1.000	ND	ND	2/2	<3.50	ND	ND	2/2
SP-5304	95.9	89.8	102	0/2	<1.000	ND	ND	2/2	<3.50	ND	ND	2/2
SP-6301	92.5	62.0	121	0/4	<1.000	ND	ND	3/3	<5.00	ND	ND	3/3
SP-6306	219	66.6	440	0/4	<1.000	ND	ND	4/4	<3.25	ND	ND	4/4

TABLE A-13 Metal Concentrations for Springs, 1993 (Continued)

	Calcium µg/l				Chromium µg/l				Cobalt µg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SP-5201	75750	63400	88100	0/2	<4.50	ND	ND	2/2	<6.00	ND	ND	2/2
SP-5303	88250	88200	88300	0/2	<4.50	ND	ND	2/2	<6.00	ND	ND	2/2
SP-5304	82850	71000	94700	0/2	<4.50	ND	ND	2/2	<6.00	ND	ND	2/2
SP-6301	39625	32400	52300	0/4	<6.00	ND	10.2	3/4	<7.33	ND	ND	3/3
SP-6306	37450	27300	53000	0/4	<4.50	ND	ND	4/4	<6.50	ND	9.60	2/4

	Copper µg/l				Iron µg/l				Lead µg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SP-5201	<5.00	ND	ND	2/2	13.2	ND	22.9	1/2	<2.00	ND	ND	2/2
SP-5303	<5.00	ND	4.10	1/2	51.4	14.2	88.6	0/2	<2.00	ND	ND	2/2
SP-5304	<5.00	ND	ND	2/2	12.8	ND	22.1	1/2	<2.00	ND	ND	2/2
SP-6301	<6.67	ND	ND	3/3	35.7	19.7	67.2	0/4	<2.00	ND	ND	4/4
SP-6306	<5.25	ND	3.89	3/4	1931	13.0	6050	0/4	<2.00	ND	ND	4/4

052094

TABLE A-13 Metal Concentrations for Springs, 1993 (Continued)

	Lithium µg/l				Magnesium µg/l				Manganese µg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SP-5201	<23.5	ND	ND	2/2	15250	11000	19500	0/2	2.35	ND	3.70	1/2
SP-5303	<23.5	ND	ND	2/2	15650	13500	17800	0/2	11.0	6.50	15.5	0/2
SP-5304	<23.5	ND	ND	2/2	12450	10200	14700	0/2	<2.00	ND	ND	2/2
SP-6301	<30.0	ND	ND	4/4	8223	6810	11400	0/4	248	ND	984	1/4
SP-6306	<25.5	ND	ND	4/4	8218	5480	11800	0/4	3608	2.90	8600	0/4

	Mercury µg/l				Molybdenum µg/l				Nickel µg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SP-5201	<0.100	ND	ND	2/2	<22.5	ND	ND	2/2	<10.00	ND	ND	2/2
SP-5303	<0.100	ND	ND	2/2	<22.5	ND	11.9	1/2	<10.00	ND	9.20	1/2
SP-5304	<0.100	ND	ND	2/2	<22.5	ND	6.30	1/2	<10.00	ND	ND	2/2
SP-6301	<0.100	ND	ND	3/3	<39.3	ND	ND	3/3	<14.25	ND	ND	4/4
SP-6306	<0.100	ND	ND	4/4	<18.0	ND	8.00	3/4	<12.25	ND	8.20	3/4

TABLE A-13 Metal Concentrations for Springs, 1993 (Continued)

	Potassium µg/l				Selenium µg/l				Silver µg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SP-5201	2475	2160	2790	0/2	<2.00	ND	3.00	1/2	<5.00	ND	ND	2/2
SP-5303	3220	2530	3910	0/2	<2.00	ND	ND	2/2	<5.00	ND	ND	2/2
SP-5304	1800	1620	1980	0/2	<2.00	ND	ND	2/2	<5.00	ND	ND	2/2
SP-6301	2618	2230	3140	0/4	<2.00	ND	2.10	2/3	<6.67	ND	ND	3/3
SP-6306	2613	2110	2930	0/4	<2.00	ND	ND	4/4	<4.75	ND	ND	4/4

	Sodium µg/l				Strontium µg/l				Thallium µg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SP-5201	7795	6710	8880	0/2	112	99.0	124	0/2	<2.00	ND	ND	2/2
SP-5303	10700	9700	11700	0/2	153	144	162	0/2	<2.00	ND	ND	2/2
SP-5304	6250	5540	6960	0/2	98.9	83.8	114	0/2	<2.00	ND	ND	2/2
SP-6301	8436	6640	12000	0/4	102	87.1	128	0/4	<2.67	ND	ND	3/3
SP-6306	9640	7260	13200	0/4	113	74.8	138	0/4	<2.50	ND	ND	4/4

TABLE A-13 Metal Concentrations for Springs, 1993 (Continued)

	Vanadium μg/l				Zinc μg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SP-5201	10.6	ND	19.7	1/2	9.90	8.70	11.1	0/2
SP-5303	13.8	ND	26.0	1/2	13.3	11.6	15.0	0/2
SP-5304	12.9	ND	24.2	1/2	10.1	9.40	10.8	0/2
SP-6301	<5.00	ND	4.70	2/3	10.7	5.80	15.8	0/3
SP-6306	8.88	ND	21.0	2/4	11.6	ND	26.2	2/4

TABLE A-14 Alkalinity , Phosphorous, and Silica Concentrations for Springs, 1993

	Alkalinity mg/l				Phosphorous mg/l				Silica, Dissolved mg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SP-5201	230	160	280	0/3	0.088	ND	0.150	1/2	10.8	8.30	13.2	0/2
SP-5303	207	160	240	0/3	0.150	0.140	0.160	0/2	11.2	11.0	11.3	0/2
SP-5304	233	190	280	0/3	0.088	ND	0.150	1/2	12.7	12.6	12.7	0/2
SP-6301	107	70.0	130	0/6	0.143	0.040	0.230	0/4	8.72	5.09	11.4	0/4
SP-6306	110	100	120	0/6	0.061	ND	0.100	1/4	11.9	10.2	15.5	0/4

TABLE A-15 Nitroaromatic Concentrations for Springs, 1993

	1,3,5-Trinitrobenzene μg/l				1,3-Dinitrobenzene μg/l				2,4,6-Trinitrotoluene μg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SP-5201	6.85	4.50	9.20	0/2	<0.090	ND	ND	2/2	76.0	32.0	120	0/2
SP-5303	0.160	0.120	0.200	0/2	<0.090	ND	ND	2/2	15.0	9.00	21.0	0/2
SP-5304	0.063	0.045	0.080	0/2	<0.090	ND	ND	2/2	1.27	0.630	1.90	0/2
SP-6301	<0.030	ND	0.043	3/4	<0.090	ND	ND	4/4	0.092	ND	0.220	1/4
SP-6306	<0.030	ND	0.029	4/5	<0.090	ND	ND	5/5	0.052	ND	0.200	4/5

	2,4-Dinitrotoluene μg/l				2,6-Dinitrotoluene μg/l				Nitrobenzene μg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SP-5201	0.121	0.041	0.200	0/2	1.03	0.760	1.30	0/2	<0.030	ND	ND	2/2
SP-5303	0.087	0.064	0.110	0/2	0.101	0.071	0.130	0/2	<0.030	ND	ND	2/2
SP-5304	0.080	0.064	0.095	0/2	0.093	0.065	0.120	0/2	<0.030	ND	ND	2/2
SP-6301	0.031	ND	0.068	2/4	0.141	ND	0.260	1/4	<0.030	ND	ND	4/4
SP-6306	<0.030	ND	0.033	3/5	0.076	ND	0.360	4/5	<0.030	ND	ND	5/5

TABLE A-16 Radiological Concentrations for Springs, 1993

	Gross Alpha pCi/l				Gross Beta pCi/l				Radium-226 pCi/l				Radium-228 pCi/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SP-5201	<2.00	1.50	---	0/1	4.50	4.50	—	0/1	<0.300	0.100	---	0/1	<1.000	0.100	---	0/1
SP-5303	130	130	---	0/1	38.0	38.0	—	0/1	0.700	0.700	---	0/1	<1.000	0.800	---	0/1
SP-5304	110	110	---	0/1	32.0	32.0	—	0/1	<0.300	0.200	---	0/1	<1.000	0.100	—	0/1
SP-6301	42.0	38.0	46.0	0/2	17.5	16.0	19.0	0/2	<0.300	0.100	0.300	0/2	<1.000	ND	0.100	1/2
SP-6306	4.55	2.80	6.30	0/2	<4.00	3.10	4.50	0/2	<0.300	ND	0.100	1/2	<1.000	ND	ND	2/2

	Thorium-228 pCi/l				Thorium-230 pCi/l				Thorium-232 pCi/l				Uranium, Total pCi/l		
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max
SP-5201	<0.400	ND	ND	1/1	<0.400	0.300	---	0/1	<0.400	ND	ND	1/1	0.775	0.300	1.30
SP-5303	<0.400	ND	ND	1/1	1.20	1.20	---	0/1	<0.400	ND	ND	1/1	105	67.0	140
SP-5304	<0.400	ND	ND	1/1	<0.400	ND	ND	1/1	<0.400	ND	ND	1/1	81.3	40.0	120
SP-6301	<0.400	ND	ND	2/2	<0.400	ND	ND	2/2	<0.400	ND	ND	2/2	32.7	6.30	50.0
SP-6306	<0.400	ND	ND	2/2	<0.400	0.100	0.300	0/2	<0.400	ND	ND	2/2	12.5	2.70	38.0

TABLE A-17 Anion Concentrations for Surface Water, 1993

	Nitrate-N MG/L				Sulfate MG/L			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SW-1001	0.140	0.140	---	0/1	25.7	25.7	---	0/1
SW-1002	<0.100	ND	ND	1/1	37.0	37.0	---	0/1
SW-1003	<0.100	ND	ND	1/1	43.2	43.2	---	0/1
SW-1004	0.130	0.130	---	0/1	32.1	32.1	---	0/1
SW-1005	0.110	0.110	---	0/1	42.9	42.9	---	0/1
SW-1007	<0.100	ND	ND	1/1	34.1	34.1	---	0/1
SW-1008	0.120	ND	0.400	4/6	122	51.1	199	0/6
SW-1009	<0.100	ND	ND	1/1	34.3	34.3	---	0/1
SW-1010	<0.100	ND	ND	1/1	38.5	38.5	---	0/1
SW-1011	2.30	2.30	---	0/1	61.3	61.3	---	0/1
SW-1012	1.70	1.70	---	0/1	65.6	65.6	---	0/1
SW-1013	1.70	1.70	---	0/1	64.2	64.2	---	0/1
SW-1014	0.680	0.680	---	0/1	29.1	29.1	---	0/1
SW-2001	0.710	0.520	0.900	0/2	20.8	18.2	23.3	0/2
SW-2002	0.335	0.240	0.430	0/2	56.9	50.2	63.6	0/2
SW-2003	1.23	0.060	2.40	0/2	12.3	10.4	14.2	0/2
SW-2004	0.885	0.370	1.40	0/2	18.2	13.4	22.9	0/2
SW-2005	0.315	0.130	0.500	0/2	23.0	19.3	26.6	0/2
SW-2007	0.540	0.400	0.680	0/2	24.9	20.4	29.3	0/2
SW-2010	0.247	ND	0.900	5/13	101	67.3	135	0/2
SW-2011	0.839	ND	4.60	1/13	54.7	32.8	76.5	0/2
SW-2012	0.760	0.760	---	0/1	12.6	12.6	---	0/1
SW-2016	0.730	0.680	0.780	0/2	22.2	18.5	25.9	0/2
SW-3001	343	125	1890	0/14	310	277	342	0/2
SW-3002	80.5	ND	224	1/14	470	322	617	0/2
SW-3003	701	9.32	1770	0/19	420	351	489	0/2
SW-3004	20.7	10.2	120	0/19	73.2	73.1	73.3	0/2

TABLE A-18 Metal Concentrations for Surface Water, 1993

	Arsenic µg/l				Barium µg/l				Cadmium µg/l				Chromium µg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SW-1001	<2.00	ND	ND	1/1	86.3	86.3	---	0/1								
SW-1002	<2.00	ND	ND	1/1	97.0	97.0	---	0/1								
SW-1003	<2.00	ND	ND	1/1	109	108	---	0/1								
SW-1004	<2.00	ND	ND	1/1	170	170	---	0/1								
SW-1006	<2.00	ND	ND	1/1	102	102	---	0/1								
SW-1007	<2.00	ND	ND	1/1	103	103	---	0/1								
SW-1008	3.60	3.60	---	0/1	31.5	31.5	---	0/1								
SW-1009	<2.00	ND	ND	1/1	105	105	---	0/1								
SW-1010	<2.00	ND	ND	1/1	104	104	---	0/1								
SW-1011	<2.00	ND	ND	1/1	104	104	---	0/1								
SW-1012	<2.00	ND	ND	1/1	95.5	95.5	---	0/1								
SW-1013	<2.00	ND	ND	1/1	104	104	---	0/1								
SW-1014	<2.00	ND	ND	1/1	85.1	85.1	---	0/1								
SW-2001	<2.00	ND	ND	1/1	73.6	73.6	---	0/1								
SW-2007	<2.00	ND	ND	1/1	72.3	72.3	---	0/1								
SW-2010	<2.00	ND	ND	1/1												
SW-2011	<2.00	ND	ND	1/1												
SW-2015	<2.00	ND	ND	1/1	87.3	87.3	---	0/1								
SW-3004	9.50	9.50	---	0/1					<5.00	ND	ND	1/1	<10.00	ND	ND	1/1

TABLE A-18 Metal Concentrations for Surface Water, 1993 (Continued)

	Lithium µg/l				Manganese µg/l				Mercury µg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SW-1001												
SW-1002												
SW-1003												
SW-1004												
SW-1005												
SW-1007												
SW-1008												
SW-1009												
SW-1010												
SW-1011												
SW-1012												
SW-1013												
SW-1014												
SW-2001												
SW-2007												
SW-2010	<20.3	ND	34.6	5/10					<0.100	ND	ND	1/1
SW-2011	<21.6	ND	27.0	8/11					<0.100	ND	ND	1/1
SW-2016												
SW-3004					11.0	11.0	—	0/1				

TABLE A-19 Alkalinity, Asbestos, TPH, and TSS Concentrations for Surface Water, 1993

	Alkalinity (mg/l)				Asbestos (mae/l)				Total Petroleum Hydrocarbons (mg/l)				Total Suspended Solids (mg/l)			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SW-1001	120	120	--	0/1												
SW-1002	175	175	--	0/1												
SW-1003	170	170	--	0/1												
SW-1004	120	120	--	0/1												
SW-1005	190	190	--	0/1												
SW-1007	170	170	—	0/1												
SW-1008	170	110	240	0/6												
SW-1009	170	170	—	0/1												
SW-1010	185	185	—	0/1												
SW-1011	135	135	—	0/1												
SW-1012	135	135	--	0/1												
SW-1013	135	135	--	0/1												
SW-1014	165	165	--	0/1												
SW-2001	111	62.0	160	0/2												
SW-2002	124	97.0	150	0/2												
SW-2003	167	64.0	270	0/2												
SW-2004	70.0	64.0	76.0	0/2												
SW-2005	38.0	1.00	75.0	0/2												
SW-2007	128	116	140	0/2												

052094

TABLE A-19 Alkalinity, Asbestos, TPH, and TSS Concentrations for Surface Water, 1993 (Continued)

	Alkalinity (mg/l)				Asbestos (mas/l)				Total Petroleum Hydrocarbons (mg/l)				Total Suspended Solids (mg/l)			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SW-2010	129	127	130	0/2	<0.185	ND	ND	2/2					4.00	ND	10.0	5/10
SW-2011	119	99.0	140	0/2	1.00	1.00	--	0/1					15.9	ND	35.0	1/11
SW-2012	40.0	40.0	--	0/1												
SW-2016	122	64.0	180	0/2												
SW-3001	55.0	42.0	68.0	0/2												
SW-3002	99.0	78.0	120	0/2					<1.100	ND	ND	1/1				
SW-3003	44.0	40.0	48.0	0/2												
SW-3004	345	330	360	0/2					<1.100	ND	ND	1/1				

TABLE A-20 Nitroaromatic Concentrations in Surface Water, 1993

	1,3,5-Trinitrobenzene µg/l				1,3-Dinitrobenzene µg/l				2,4,6-Trinitrotoluene µg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SW-1001	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	0.032	0.032	--	0/1
SW-1002	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1003	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1004	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1005	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1007	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1008	1.39	ND	5.80	2/6	<0.177	ND	ND	6/6	50.9	1.30	190	0/6
SW-1009	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1010	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1011	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1012	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1013	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1014	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	<0.030	ND	ND	1/1
SW-3001	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	<0.030	ND	ND	1/1
SW-3002	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	<0.030	ND	ND	1/1
SW-3003	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	<0.030	ND	ND	1/1
SW-3004	<0.030	ND	ND	1/1	<0.090	ND	ND	1/1	<0.030	ND	ND	1/1

TABLE A-20 Nitroaromatic Concentrations in Surface Water, 1993 (Continued)

	2,4-Dinitrotoluene μg/l				2,6-Dinitrotoluene μg/l				Nitrobenzene μg/l			
Location	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SW-1001	<0.030	ND	ND	1/1	0.026	0.026	—	0/1	<0.030	ND	ND	1/1
SW-1002	<0.030	ND	ND	1/1	0.011	0.011	—	0/1	<0.030	ND	ND	1/1
SW-1003	<0.030	ND	ND	1/1	<0.010	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1004	<0.030	ND	ND	1/1	<0.010	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1005	<0.030	ND	ND	1/1	<0.010	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1007	<0.030	ND	ND	1/1	<0.010	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1008	4.44	ND	14.0	1/6	0.996	ND	1.80	1/6	<0.213	ND	ND	6/6
SW-1009	<0.030	ND	ND	1/1	<0.010	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1010	<0.030	ND	ND	1/1	<0.010	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1011	<0.030	ND	ND	1/1	<0.010	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1012	<0.030	ND	ND	1/1	<0.010	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1013	<0.030	ND	ND	1/1	<0.010	ND	ND	1/1	<0.030	ND	ND	1/1
SW-1014	<0.030	ND	ND	1/1	<0.010	ND	ND	1/1	<0.030	ND	ND	1/1
SW-3001	<0.030	ND	ND	1/1	<0.010	ND	ND	1/1	<0.030	ND	ND	1/1
SW-3002	<0.030	ND	ND	1/1	<0.010	ND	ND	1/1	<0.030	ND	ND	1/1
SW-3003	<0.030	ND	ND	1/1	<0.010	ND	ND	1/1	<0.030	ND	ND	1/1
SW-3004	<0.025	ND	ND	2/2	<0.010	ND	ND	1/1	<0.030	ND	ND	1/1

TABLE A-21 Radiological Concentrations in Surface Water, 1993

Location	Actinium-227 pCi/l				Gross Alpha pCi/l				Gross Beta pCi/l				Radium-226 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SW-1001					<2.000	ND	ND	0/1	10.0	10.0	---	0/1	<0.300	0.200	---	0/1
SW-1002					3.40	3.40	---	0/1	<4.00	3.90	---	0/1	1.10	1.10	---	0/1
SW-1003					87.0	87.0	---	0/1	48.0	48.0	---	0/1	1.50	1.50	---	0/1
SW-1004					81.0	81.0	---	0/1	33.0	33.0	---	0/1	0.900	0.900	---	0/1
SW-1005					58.0	58.0	---	0/1	39.0	39.0	---	0/1	0.700	0.700	---	0/1
SW-1007					39.0	39.0	---	0/1	21.0	21.0	---	0/1	1.30	1.30	---	0/1
SW-1008					3132	240	6800	0/6	1151	93.0	2860	0/6	0.617	ND	1.50	2/6
SW-1009					26.0	26.0	---	0/1	17.0	17.0	---	0/1	0.700	0.700	---	0/1
SW-1010					53.0	53.0	---	0/1	32.0	32.0	---	0/1	0.600	0.600	---	0/1
SW-1011					13.0	1.10	64.0	0/29	20.4	6.40	100	0/29	1.07	ND	4.74	3/29
SW-1012					15.4	7.90	21.0	0/5	20.0	17.0	26.0	0/5	1.36	0.700	2.30	0/5
SW-1013					6.20	6.20	---	0/1	20.0	20.0	---	0/1	0.700	0.700	---	0/1
SW-1014					<2.000	ND	ND	0/1	<4.00	3.60	---	0/1	0.400	0.400	---	0/1
SW-1015					6.19	ND	30.0	2/52	12.0	2.00	39.0	0/52	0.727	ND	2.70	7/51
SW-2001					2.10	2.10	---	0/1	4.70	4.70	---	0/1	1.20	1.20	---	0/1
SW-2002					21.0	21.0	---	0/1	12.0	12.0	---	0/1	0.500	0.500	---	0/1
SW-2003	<25.0	ND	ND	1/1	9.00	9.00	---	0/1	4.90	4.90	---	0/1	<0.300	ND	ND	1/1
SW-2004	<25.0	ND	ND	1/1	7.60	7.60	---	0/1	5.10	5.10	---	0/1	<0.300	ND	ND	1/1
SW-2005	<25.0	ND	ND	1/1	17.0	17.0	---	0/1	6.90	6.90	---	0/1	<0.300	ND	ND	1/1

TABLE A-21 Radiological Concentrations in Surface Water, 1993 (Continued)

Location	Actinium-227 pCi/l				Gross Alpha pCi/l				Gross Beta pCi/l				Radium-226 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SW-2007					3.20	3.20	—	0/1	6.70	6.70	—	0/1	<0.300	ND	ND	1/1
SW-2010					1439	286	2660	0/12	347	41.7	700	0/12	2.30	2.30	—	0/1
SW-2011					387	90.8	1530	0/12	78.3	30.8	284	0/12	0.900	0.900	—	0/1
SW-2012					12.0	12.0	—	0/1	9.30	9.30	—	0/1	0.600	0.600	—	0/1
SW-2016					<2.000	0.700	—	0/1	8.60	8.60	—	0/1	<0.300	ND	ND	1/1
SW-3001					190	190	—	0/1	46.0	46.0	—	0/1	71.0	71.0	—	0/1
SW-3002					480	480	—	0/1	120	120	—	0/1	32.0	32.0	—	0/1
SW-3003					1380	1380	—	0/1	610	610	—	0/1	30.0	30.0	—	0/1
SW-3004					4860	4860	—	0/1	1050	1050	—	0/1	2.90	2.90	—	0/1

TABLE A-21 Radiological Concentrations in Surface Water, 1993 (Continued)

Location	Radium-228 pCi/l				Radon-222 pCi/l				Thorium-228 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SW-1001	<1.000	0.400	---	0/1					<0.400	ND	ND	0/1
SW-1002	<1.000	ND	ND	0/1					<0.400	ND	ND	0/1
SW-1003	<1.000	0.200	---	0/1					<0.400	ND	ND	0/1
SW-1004	<1.000	ND	ND	0/1					<0.400	ND	ND	0/1
SW-1006	<1.000	0.200	---	0/1					<0.400	ND	ND	0/1
SW-1007	<1.000	0.400	---	0/1					<0.400	ND	ND	0/1
SW-1008	<1.000	ND	0.600	1/6					<0.400	ND	ND	6/6
SW-1009	<1.000	ND	ND	0/1					<0.400	ND	ND	0/1
SW-1010	<1.000	ND	ND	0/1					<0.400	ND	ND	0/1
SW-1011	<0.902	ND	2.00	6/29					<4.24	ND	66.5	7/29
SW-1012	<1.000	ND	0.500	1/6					0.860	0.400	1.30	0/5
SW-1013	<1.000	ND	ND	0/1					1.00	1.00	—	0/1
SW-1014	<1.000	ND	ND	0/1					<0.400	ND	ND	0/1
SW-1015	<0.882	ND	2.10	12/51					<0.344	ND	2.00	28/52
SW-2001	1.10	1.10	---	0/1					<0.400	ND	ND	1/1
SW-2002	<1.000	0.200	---	0/1					<0.400	ND	ND	1/1
SW-2003	<1.000	0.300	---	0/1					<0.400	0.100	---	0/1
SW-2004	<1.000	0.200	---	0/1					<0.400	ND	ND	1/1
SW-2005	<1.000	ND	ND	1/1					<0.400	ND	ND	1/1

052094

TABLE A-21 Radiological Concentrations in Surface Water, 1993 (Continued)

Location	Radium-228 pCi/l				Radon-222 pCi/l				Thorium-228 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SW-2007	<1.000	ND	ND	1/1					<0.400	0.100	—	0/1
SW-2010	<1.000	0.500	—	0/1					<0.400	ND	ND	1/1
SW-2011	<1.000	0.600	—	0/1					<0.400	ND	ND	1/1
SW-2012	<1.000	0.300	—	0/1					<0.400	0.200	—	0/1
SW-2016	<1.000	0.300	—	0/1					<0.400	ND	ND	1/1
SW-3001	3.70	3.70	—	0/1	958	ND	1800	1/3	<0.400	ND	ND	1/1
SW-3002	6.00	6.00	—	0/1	2157	1300	3370	0/3	<0.400	0.300	—	0/1
SW-3003	17.0	17.0	—	0/1	368	ND	530	1/3	<0.400	ND	ND	1/1
SW-3004	12.0	12.0	—	0/1	295	ND	590	1/3	<0.400	ND	ND	1/1

TABLE A-21 Radiological Concentrations in Surface Water, 1993 (Continued)

Location	Thorium-230 pCi/l				Thorium-232 pCi/l				Uranium, Total pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SW-1001	1.10	1.10	—	0/1	<0.400	0.200	—	0/1	0.983	ND	2.60	1/6
SW-1002	<0.400	0.300	---	0/1	<0.400	ND	ND	0/1	0.950	0.600	1.80	0/5
SW-1003	0.500	0.500	---	0/1	<0.400	0.400	---	0/1	51.7	4.10	150	0/6
SW-1004	<0.400	0.100	---	0/1	<0.400	0.200	---	0/1	723	25.0	4000	0/6
SW-1005	0.600	0.600	---	0/1	<0.400	ND	ND	0/1	37.0	2.90	91.0	0/6
SW-1007	<0.400	ND	ND	0/1	<0.400	ND	ND	0/1	19.1	2.80	38.0	0/7
SW-1008	2.48	0.700	4.40	0/6	<0.400	ND	0.600	3/6	3657	360	9000	0/6
SW-1009	0.600	0.600	—	0/1	<0.400	ND	ND	0/1	17.2	3.90	27.0	0/6
SW-1010	1.10	1.10	---	0/1	<0.400	ND	ND	0/1	43.3	18.0	66.0	0/4
SW-1011	4.11	ND	83.8	1/29	<4.09	ND	69.7	5/29	4.01	ND	9.90	1/31
SW-1012	1.48	0.700	2.60	0/5	1.02	0.400	1.70	0/5	5.09	2.70	8.30	0/9
SW-1013	1.60	1.60	—	0/1	0.500	0.500	—	0/1	3.62	2.70	4.90	0/5
SW-1014	3.10	3.10	—	0/1	<0.400	ND	ND	0/1	0.950	0.400	1.90	0/4
SW-1015	0.944	ND	4.30	9/62	<0.355	ND	0.850	23/62	2.68	ND	11.0	5/52
SW-2001	1.30	1.30	---	0/1	<0.400	ND	ND	1/1	3.95	1.80	10.0	0/4
SW-2002	<0.400	0.400	---	0/1	<0.400	ND	ND	1/1	79.8	19.0	130	0/4
SW-2003	<0.400	0.400	---	0/1	<0.400	ND	ND	1/1	9.30	6.70	12.0	0/4
SW-2004	0.500	0.500	---	0/1	<0.400	ND	ND	1/1	10.2	6.60	16.0	0/4
SW-2005	0.700	0.700	---	0/1	<0.400	ND	ND	1/1	26.5	19.0	35.0	0/4

TABLE A-21 Radiological Concentrations in Surface Water, 1993 (Continued)

Location	Thorium-230 pCi/l				Thorium-232 pCi/l				Uranium, Total pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SW-2007	<0.400	0.400	—	0/1	<0.400	ND	ND	1/1	1.15	0.500	1.80	0/4
SW-2010	<0.400	0.100	—	0/1	<0.400	ND	ND	1/1	1971	214	5100	0/15
SW-2011	<0.400	ND	ND	1/1	<0.400	0.100	—	0/1	357	116	1040	0/15
SW-2012	0.900	0.900	—	0/1	<0.400	ND	ND	1/1	9.20	8.50	9.90	0/2
SW-2016	0.800	0.800	—	0/1	<0.400	ND	ND	1/1	2.08	1.60	2.60	0/4
SW-3001	14.0	14.0	—	0/1	1.10	1.10	—	0/1	120	120	—	0/2
SW-3002	13.0	13.0	—	0/1	2.00	2.00	—	0/1	905	610	1200	0/2
SW-3003	1.10	1.10	—	0/1	<0.400	ND	ND	1/1	475	430	520	0/2
SW-3004	<0.400	0.200	—	0/1	<0.400	ND	ND	1/1	1677	1600	1800	0/3

TABLE A-21 Radiological Concentrations in Surface Water, 1993 (Continued)

Location	Uranium-234 pCi/l				Uranium-235 pCi/l				Uranium-238 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SW-1001												
SW-1002												
SW-1003												
SW-1004												
SW-1005												
SW-1007												
SW-1008												
SW-1009												
SW-1010												
SW-1011												
SW-1012												
SW-1013												
SW-1014												
SW-1015												
SW-2001	1.60	1.60	--	0/1	<0.400	ND	ND	1/1	1.20	1.20	--	0/1
SW-2002												
SW-2003												
SW-2004												
SW-2005												

TABLE A-21 Radiological Concentrations in Surface Water, 1993 (Continued)

Location	Uranium-234 pCi/l				Uranium-235 pCi/l				Uranium-238 pCi/l			
	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio	Avg	Min	Max	Ratio
SW-2007												
SW-2010												
SW-2011												
SW-2012												
SW-2016												
SW-3001	32.0	32.0	—	0/1	0.900	0.900	—	0/1	38.0	38.0	—	0/1
SW-3002	80.0	80.0	—	0/1	5.70	5.70	—	0/1	160	160	—	0/1
SW-3003	230	230	—	0/1	7.10	7.10	—	0/1	220	220	—	0/1
SW-3004	820	820	—	0/1	25.0	25.0	—	0/1	810	810	—	0/1

APPENDIX B
Assumptions and Scenarios for Dose Calculations

A. Dose from the chemical plant/raffinate pits to a maximally exposed individual.

1. Inhalation :

   a. Airborne particulate: Statistical analysis of gross alpha results indicated that four stations were different than background levels. One of the stations is used to monitor airborne concentrations at the WSSRAP administration building and two of these stations were located on the northern and western perimeters of the site boundary. The final station is located near the August A. Busch Memorial Conservation Area headquarters building and was used to evaluate the dose from the chemical plant/raffinate pits to a hypothetical maximally exposed individual. While accessible to a member of the public, the perimeter and administration building locations do not have airborne concentrations that when combined with realistic exposure times which would provide a dose greater than the calculation provided for the Busch Memorial Conservation Area. The net gross alpha concentration at the Busch Memorial Conservation Area was 2.2E-16 μCi/ml or 2.2E-7 pCi/m^3 and was assumed to be natural uranium. An exposure time of 132.5 hours (see ingestion pathway below) was also used in the dose estimate.

CEDE(inhalation)	=	net airborne particulate concentration x exposure time x breathing rate x dose conversion factor (DCF[1])
	=	2.2E-7 pCi/m^3 x 132.5 hr x 0.96 m^3/hr x 1.32E-1 mrem/pCi
	=	3.69E-6 mrem

   b. Radon Gas: No contribution to the estimated EDE for the hypothetical individual was calculated for radon gas. Based on the statistical analysis of the data collected, there is no reason to suspect at the 95% confidence level that the measured results from any of the monitoring locations were greater than background.

2. External gamma pathway: External gamma radiation: no contribution to the estimated EDE for the hypothetical individual was calculated for external gamma radiation. Based on the statistical analysis of the data collected, there is no reason to suspect at the 95%

confidence level that the measured results from any of the monitoring locations were greater than background.

3. Ingestion pathway: Lakes that receive effluent from the chemical plant/raffinate pits are used in order to determine the estimated effective dose equivalent to a maximally exposed individual via ingestion of fish, water, and sediment obtained from these lakes.

   On average, fishing at the Busch Conservation Area requires 3.5 hours per visit (Ref.21). Assume that the maximally exposed individual visited the lakes for the purpose of fishing 25 times during the year. The ratio of fish caught to hours spent fishing is estimated at 0.40, while the ratio of fish kept is estimated at 0.5. Thus on an annual basis, the maximally exposed individual would keep 12.3 fish from the lakes. Assume that the edible portion of fish has an average mass of 200 g. Thus the annual consumption rate of 6.5 g/day provides a good estimate of the consumption rate for fish caught from the three affected lakes for the hypothetical individual.

   Boating at the Busch Memorial Conservation Area requires more hours per visit than any other activity; therefore, boating was assumed to be the activity in which the maximally exposed individual participated for the water and sediment ingestion scenarios. Assume the average time spent by the maximally exposed individual per boating trip is 4.5 hours, and the hypothetical individual visits the area for the purpose of boating 10 times in a year. Assume 25% of the time is devoted to swimming during each visit. Thus, 11.25 hours is spent swimming in the lakes.

   a. Fish: Assume a 6.5 g/day fresh water fish consumption rate from Lake 36 at the Busch Memorial Conservation Area and a 0.009 pCi/g (0.0003 Bq/g) total uranium content in fish of all lakes receiving runoff from the Weldon Spring site.

   b. Water: Assume a 0.05 l/hour swimming ingestion rate for the 11.25 hours for a total annual consumption of 0.56 liters. The water is assumed to have a total uranium concentration of 130 pCi uranium/l, as detected in Lake 36, which is the highest uranium concentrations of all lakes receiving runoff from the site.

c. Sediment: Assume a 200 mg/day ingestion rate for the 11.25 hours for a total of 94 mg of sediment. The sediment is assumed to have a total uranium concentration of 110 pCi uranium/g sediment, as detected in Lake 34, which is the highest uranium concentration of all lakes receiving runoff from the site.

CEDE (ingestion) = annual fish consumption x uranium concentration x uranium DCF + annual water consumption x uranium concentration x uranium DCF + annual sediment ingestion x uranium concentration x uranium DCF[1]

= 6.5 g/day x 365 day/year x 0.009 pCi/g x 2.83E-4 mrem/pCi + 0.56 l/year x 130 pCi/l x 2.83E-4 mrem/pCi + 0.094 g/year x 110 pCi/g x 2.83E-4 mrem/pCi

= 0.03 mrem (0.0003 mSv)

The total estimated committed effective dose equivalent to the maximally exposed individual at the chemical plant/raffinate pits area is 0.03 mrem (0.0003 mSv).

B. Dose from the Weldon Spring Quarry to a maximally exposed individual.

1. Inhalation pathway:

a. Airborne radioactive particulate: Not applicable since there is no reason to suspect at the 95% confidence level that airborne radioactive particulate data are greater than background concentrations.

b. Radon Gas: Assume the concentration at Missouri State Route 94 is equal to the measured net concentration at RD-1002 of 1.3 pCi/l. Assume an annual exposure time of 50 hours (Section 4.2.2).

Radon concentrations are often expressed in units of working levels (WL) where 1 WL = 100 pCi/l for Rn-222. Radon exposure is often expressed in terms of working level month (WLM) which corresponds to an exposure of

1 WL during the reference working period of 1 month (i.e. 2000 working hours per 12 months or 170 hours). Assume a working level ratio for Rn-222 of 50% and a dose conversion factor of 1 rem/WLM (Ref. 27).

CEDE(inhalation) = net radon concentration x exposure time x working level ratio x dose conversion factor x working month dose conversion factor[1].

= 1.3 pCi/l x 50 hours x 0.50 x 1 WL/100 pCi/l x 1.00 rem/WLM x 1 working month/170 hours x 1000 mrem/rem

= 1.9 mrem

2. External gamma pathway: Not applicable because there is no reason to suspect at the 95% confidence level that external gamma radiation results at the quarry monitoring locations are greater than background.

3. Ingestion pathway: Because the quarry is controlled by a 2.4 m (8 ft) high fence, fishing, swimming, and drinking water at the quarry do not constitute realistic scenarios.

   The total estimated committed effective dose equivalent to a maximally exposed individual at the quarry is 1.91 mrem (0.0191 mSv).

C. Dose from the vicinity properties to a maximally exposed individual.

   1. Inhalation pathway: Statistical analysis of airborne particulate and radon concentrations indicate that there is no reason to suspect at the 95% confidence level any contributions via these pathways.

   2. External gamma pathway: Not applicable since there is no reason to suspect at the 95% confidence level that external gamma radiation data are greater than background.

   3. Ingestion pathway: A slough located adjacent to the quarry contains uranium contaminated sediments and was used to determine estimated effective dose

equivalent to a hypothetical individual via ingestion of fish. Ingestion of water or sediments was not assumed due to the stagnant condition of the water.

Fish: Assume a 6.5 g/day fresh water fish consumption rate (Ref. 23) from the slough. Assume the average uranium concentration in fish collected from the slough of 0.002 pCi/g.

$$\text{CEDE} = \text{Fish consumption x uranium concentration x DCF}^{1}$$

$$= 6.5 \text{ g/day x } 365 \text{ d/yr x } 0.002 \text{ pCi/g x } 2.83\text{E-04 mrem/pCi}$$

$$= 0.0013 \text{ mrem } (0.000013 \text{ mSv})$$

The total estimated committed effective dose equivalent for the maximally exposed individual at the Little Femme Osage Slough is 0.0013 mrem (0.000013 mSv).

D. Collective Population Dose Estimate

Exposure Points - Exposure points are locations where members of the public are potentially being exposed to above-background concentrations of (1) airborne radioactive particulates, (2) radon gas concentrations, (3) external gamma radiation, or (4) radionuclides in food or water. All three pathways are addressed for the collective population dose estimate. Exposure to above-background radionuclide concentrations in food or water is addressed only for users of the Busch Conservation Area, a recreational area adjacent to the chemical plant/raffinate pits area. Three of the lakes on this property receive runoff from the site and are used by the general public for fishing and boating purposes. None of these bodies of water are used as drinking water sources.

Exposure points, by definition, must be located where there is potential for public exposure as a result of activities performed at the site or from materials stored at the site. If there is no reason to suspect that environmental monitoring results are different from the appropriate background monitoring results, then the area surrounding the environmental monitoring station cannot be considered an exposure point; therefore, the population near the station, as well as the population beyond the station, is not included in the collective population dose estimate.

The only area where there was reason to suspect that environmental monitoring results could be different than the appropriate background monitoring results was at the quarry perimeter. This was true only for radon concentrations. The only potential receptors near the quarry perimeter are people using the Katy Trail, a recreational hiking and biking trail located on state-owned land south of the quarry. However, track etch detectors placed at the trail indicate that there was no reason to suspect at the 95% confidence level that concentrations exceeded background. As a result, no collective dose was calculated for the population that frequents the Katy Trail.

The Katy Trail was chosen as the only public exposure point near the quarry because at all environmental monitoring locations near the quarry (i.e., AP-4011, and RD-4006), there was no reason to suspect at the 95% confidence level that the monitoring results were different from the background monitoring results.

The only area where there was reason to suspect that a significant amount of the general population could consume fish, water, and sediments from waters that receive runoff from the site was at the Busch Memorial Conservation Area. The only potential receptors in that area are the people who actually use the Busch Memorial Conservation property for recreational purposes. Three of the lakes at the area (i.e., Lakes 34, 35, and 36) receive runoff from the Weldon Spring site and are utilized for fishing and boating activities. The Missouri Department of Conservation recently conducted a year long survey to determine the number of visitors to the area, the types of activities in which users participate, and the amount of time allocated for these activities.

Fishing at the Busch Conservation Area averaged 3.5 hours per visit for the approximately 160,000 visits to the area for that purpose (assuming a time-spent to fish-caught ratio of 0.4 fish/hour and a 0.50 ratio of fish caught to fish kept for a total of 112,000 persons). Assuming that one person keeps one fish, the population of concern would be 112,000 persons. For the water and sediment ingestion scenarios, boating is the activity assumed to provide the potential for incidental water and sediment ingestion. An estimated 5,985 visits were made for the purpose of boating with an average of 4.5 hours per visit. Assuming that each visit constitutes one individual, the total population would be 5,985 persons. Each of these ingestion scenarios is further addressed in calculations one, two, and three.

Although data from three radon track etch stations at the perimeter of the raffinate pits were found to be statistically greater than background, it is not realistic to calculate a population dose based on the concentrations that were measured. The annual averages for the stations were less than 0.1 pCi/l greater than the annual average of the background stations. In addition, at all off-site monitoring stations in the vicinity of the chemical plant/raffinate pits there was no reason to suspect at the 95% confidence level that any of the stations were greater than background. As a result, no dose was calculated for the population that frequents the Busch Memorial Conservation Area.

The only on-site location where statistical analysis of gross alpha results from airborne particulate samples was greater than background was at the Busch Memorial Conservation Area. Although NESHAPs monitoring results indicated no above background concentrations of uranium or other isotope that would have orginated from the chemical plant area, the above background measurements will be assumed to have originated from the chemical plant until it can be shown to be otherwise.

1. Population dose estimate due to ingestion of fish obtained at the Busch Memorial Conservation Area.

    a. Assuming that each person of the 112,000 population consumes one fish and that the edible portion of a fish has a mass of 200 g, the average consumption rate specific to the affected population is 0.55 g/person/day.

    b. Using the total uranium fish content of 0.017 pCi/g obtained from samples collected in Lake 36 and the population specific consumption rate derived from Missouri Department of Conservation data, the estimated population dose is:

Population Dose Estimate (fish ingestion) = consumption rate x total uranium concentration in fish x exposure time x dose conversation factor[1] x persons

1 Uranium dose conversion factor (DCF) was the greater of the two DCFs reported for each uranium isotope (U-234 and U-238) in Table 2.2 of Eckerman et al. (Ref. 21)

$$= 0.55 \ \frac{g}{day} \ x \ 0.017 \ \frac{pCi}{g} \ x \ 365 \ day \ x \ 2.83E{-4} \ \frac{mrem}{pCi}$$

$$x \quad 112{,}000 \ persons \ x \ \frac{1 \ rem}{1{,}000 \ mrem}$$

$$= 0.1 \ person{-}rem$$

2. Population dose estimate due to incidental ingestion of water at the Busch Conservation lakes.

    a. Assume that each person of the 5985 population makes one boating visit on an annual basis and 25% of the visit is spent swimming (1.125 hours/visit).

    b. Using the total uranium surface water content of 51 pCi/l obtained from Lake 36 and an ingestion rate of 0.05 l/hour (Ref. 23) the estimated population dose is

Population Dose Estimate (water ingestion) = ingestion rate x total uranium concentration in surface water x exposure time x dose conversation factor(1) x persons

$$= 0.05 \ \frac{l}{hr} \ x \ 51 \ \frac{pCi}{l} \ x \ 1.125 \ hr \ x \ 2.83E{-4} \ \frac{mrem}{pCi}$$

$$x \ 5985 \ persons \ x \ \frac{1 \ rem}{1{,}000 \ mrem}$$

$$= 0.016 \ person \ rem$$

3. Population dose estimate due to ingestion of sediments at the Busch lakes.

    a. Assume that each person of the 5,985 population makes one boating visit on an annual basis and 25% of the visit is spent swimming (1.125 hours/visit).

    b. Using the total uranium sediment content of 110pCi/g obtained from Lake 34 and an ingestion rate of 200 mg/day, the estimated population dose is:

Population Dose Estimate (sediment ingestion) = ingestion rate x total uranium concentration in sediment x exposure time x dose conversion factor[1] x persons

$$= 200\ \frac{mg}{day} \times \frac{1\ g}{1{,}000\ mg} \times 110\ \frac{pCi}{g} \times 1.125\ hr \times \frac{1\ day}{24\ hr} \times 2.83E{-4}\ \frac{mrem}{pCi}$$
$$\times\ 5{,}985\ persons \times \frac{1\ rem}{1{,}000\ mrem}$$
$$= 0.0017\ person{-}rem$$

4. Population dose estimate due to inhalation of airborne particulate.

a. Assume a population of 5,985 persons visit the area for the purpose of boating and each person spends 4.5 hours per visit.

b. Assume a population of 160,000 persons visit the area for the purpose of fishing and each person spends 3.5 hours fishing.

c. Assume an airborne concentration of 2.2E-7 pCi/m^3.

CEDE (inhalation) = net airborne concentration x exposure time for boating x breathing rate x dose conversion factor (DCF^1) x boating population + net airborne concentration x exposure time for fishing x breathing rate x dose conversion factor (DCF^1) x fishing population.

= 2.2E-7 pCi/m^3 x 4.5 hr x 0.96 m^3/hr x 1.32E-1 mrem/pCi x 1 rem/1,000 mrem x 5985 person + 2.2E-7 pCi/m^3 x 3.5 hour x 0.96 m^3/hr x 1.32 E-1 mrem/pCi x 1 rem/1000 mrem x 160,000 person

= 1.56E-5 person-rem

The total estimated population dose for all potential exposure pathways for calendar year 1993 is 0.12 person-rem.

E. U-238, U-235, and U-234 Release Estimates

To estimate U-238, U-235, and U-234 total airborne releases from the chemical plant, the above background NESHAPs concentrations were incorporated into a box model. The above background U-238, U-235, and U-234 measurements resulted from building dismantlement/demolition activities conducted during 1993. Because these fugitive dust sources had continuously changing source terms, emission rates, emission locations and area size, dependent on the work in progress as well as various other variables, an accurate determination of the contributions from each of the sources is impossible. Thus a simple box model was used to estimate total releases from all activities. The box model assumes that the airborne contaminants are dispersed homogeneously within the modeled volume of air. The selected length for the model was 366 m (400 yd); for height 15.2 m (16.7 yd); and the value for average wind speed was 4.5 m/s (10 mph). The average net concentration of 1.34E-16 μCi/ml, the highest above background total uranium NESHAPs concentration measured at AP-2005, was also used in the release estimate. NESHAPs filters were analyzed for total uranium and to estimate isotopic releases natural uranium ratios were assumed. A simplified box model is justified for calculating the airborne particulate release since the activity released is low as indicated by calculation results.

Box Model: length = 366 m (400 yd), height = 15.2 m (16.7 yd), average wind speed = 4.5 m/s (10 mph), seconds per year = 3.16E7 seconds.

Release total = length x height x wind speed x airborne concentration x seconds/year = 1.057E-3 Ci total uranium

U-238 - 1.06E-3 Ci x 0.4862 (U-238 natural uranium ratio) = 5.14E-4 Ci

U-235 = 1.06E-3 Ci x 0.0227 (U-235 natural uranium ratio) = 2.40E-5 Ci

U-234 = 1.06E-3 Ci x 0.4911 (U-234 natural uranium ratio) = 5.19E-4 Ci

F. Radon Release Estimate

To estimate airborne radon progeny concentrations at the Katy Trail, the above-background radon results measured at the WSQ perimeter were incorporated into a box model. A box model predicts the radon release rate in pCi/y by multiplying the measured net airborne or radon concentration by the assumed box model parameters for length, height, and average annual wind speed. The box model assumes that airborne contaminants are dispersed homogeneously within the modeled volume of air. The selected value for model length is 122 m (134 yd); for height it is 3 m (3.3 yd); and the value for average annual wind speed is 4.5 m/s (10 mi/hour). The model length value corresponds to the length of the major contaminated area within the quarry. A simplified box model is justified for calculating the airborne radon release rate since the effective dose equivalent and population doses are low as indicated by the calculation results.

The net annual average radon concentration at the WSQ is 0.24 pCi/l and is calculated by averaging the results from stations RD-1002 through RD-1009 less the average background result of 0.10 pCi/l.

Box Model: length = 122 m (134 yd), height = 3 m (3.3 yd), average wind speed (μ) = 4.5 m/s (10 mi/hour), seconds per year = 3.16E7 seconds.

Release rate = length x height x μ x net annual average radon concentration x seconds/year = 12.5 Ci/y.

APPENDIX C
Unpublished Documents

UNIVERSITY OF MISSOURI-ST. LOUIS
Urban Information Center

Office of Computing and Networking Services

8001 Natural Bridge Road
St. Louis, Missouri 63121-4499
Telephone: (314) 553-6000
Fax: (314) 553-6007

November 24, 1993

Ms. Julie M. Reitinger
MK-Ferguson Company
7295 Highway 94 South
St. Charles, MO 63304

Dear Ms. Reitinger,

Following is that data you requested.:

Counties	1990	Estimated 1991
Missouri:		
St. Louis (city)	396,685	392,160
St. Louis County	993,529	997,067
Franklin	80,603	82,130
Jefferson	171,380	174,663
St. Charles	212,907	218,997
Lincoln	28,892	29,903
Warren	19,534	20,201
Illinois:		
Madison	249,238	249,000
St. Clair	262,852	264,100
Clinton	33,944	33,700
Monroe	22,422	21,900
Jersey	20,539	20,600
1990 St. Louis MSA	2,444,099	2,454,317
1993 defined St. Louis MSA	2,492,525	2,504,421

June 1992 the Office of Management and Budget redefined Metropolitan areas, Warren and Lincoln counties in Missouri were added to the St. Louis MSA.

Following are data for selected cities:

Cities	1990	Revised 1990 Census
Cottleville	2,936	453
New Melle	481	206
O'Fallon	18,698	17,427
St. Charles City	54,555	50,634
St. Peters	45,779	40,660
Weldon Spring	1,470	1,034
Weldon Spring Heights	75	97
Wentzville	5,140	4,640
Lake St. Louis	7,400	7,536
Dardenne Prairie	1,769	735

In early spring there will be population estimates for cities, and then estimates about every two years, along with county estimates.

If you have any questions call me at 553-6035.

Sincerely,

Linda C. McDaniel

Linda C. McDaniel
Public Data Information Specialist

MISSOURI DEPARTMENT OF
HEALTH

Mel Carnahan
Governor

Coleen Kivlahan, M.D., M.S.P.H.
Director

P.O. Box 570; Jefferson City, MO 65102-0570 • 314-751-6400 • FAX 314-751-6010

February 24, 1994

Mr. Steve McCracken
7295 Highway 94 South
St. Charles, MO 63304

Dear Mr. McCracken:

The Missouri Department of Health has been involved in a surveillance system devised to monitor the Department of Energy in its cleanup of the Weldon Spring Chemical Plant Site from 1988 to the present. This system involves the sampling of selected area wells for analytes whose presence would be indicative of contamination from the site.

Since beginning this system, we've observed no significant changes in the levels of any of the substances for which the samples were analyzed. Also, there is no indication that contaminants from the site are affecting the wells.

This information is being sent to you per the request of Mr. Jim Meier of MK Ferguson.

Sincerely,

Daryl W. Roberts
Chief
Bureau of Environmental Epidemiology

DWR:SAC

1

MORRISON KNUDSEN CORPORATION
MK-FERGUSON GROUP

Report of Telecon

To: Julie Reitinger
From: Linda Meyer

Incoming: ___ Outgoing: X WP#: ___
Date: 11-5-93 Time: 1:45

Conversation With:
Diane Oakly
of: Francis Howell School District
and:
of:

Phone: 441-0088

Phone:

Subject: Number of Students and Employees at Francis Howell High School

Summary of Conversation:
Asked Diane Oakly the # of Students and employees at The Francis Howell High School and the "Annex"

High School
Students - 1,926
Faculty - 112
Admin - 5
Support Staff 28

Annex
# of Employees Reporting to Annex 29
# of Employees at Annex Full time 5
(The rest are in and out during the day)

Action of Follow-Up/Recommendations:

cc: RC-25-01-12
Mary Picel
Dick Hursey

By: Linda L. Meyer

ENG-6a.3 Rev.2 10/92

MORRISON KNUDSEN CORPORATION
MK-FERGUSON GROUP

Report of Telecon

To: M. Lutz
From: K. Warburton

Incoming: ___ Outgoing: — WP#: —
Date: 11-18-93 Time: 1330

Conversation With:
Roy Grimes
of: MDC
and: K. Warburton
of: PMC

Phone: 441-8554

Phone: x2933

Subject: Personnel at Busch Office

Summary of Conversation:

Roy indicated the following numbers of personnel operate out of the Busch conservation Area Headquarters office:

Permanent, Full Time Staff – 25
Seasonal/Summer Staff – Varies from 2 to 10

Action of Follow-Up/Recommendations:
Route Info to M. Lutz.

cc: EN-22-16 (Hummel/File)
J. Williams

By: Kenyon R. Warburton

ENG-6a.3 Rev.2 10/92

MORRISON KNUDSEN CORPORATION
MK-FERGUSON GROUP

Report of Telecon

To: Melissa Lutz
From: Metha Sizemore

Incoming: ___ Outgoing: X WP#: -
Date: 12/28/93 Time: 0850

Conversation With: Bill Livers
of: Highway maintenance Department
and: Metha Sizemore
of: PMC

Phone: 441-8471
Phone: 314-441-8086 x2702

Subject: Number of employees at the highway maintenance

Summary of Conversation:

There are nine full time employees at the state highway department maintenance shop adjacent to the Weldon Spring Chemical Plant.

Action of Follow-Up/Recommendations:

Yearly update for inclusion in the annual site environmental report

CC: 1993 ASER File

By: Metha D. Sizemore

ENG-6a.3 Rev.2 10/92

DISTRIBUTION LIST

CONGRESSIONAL:

The Honorable Christopher S. Bond
U.S. Senate
SR-293 Russell Senate Office Building
Washington, D.C. 20510-2503

The Honorable John Danforth (letters & newsletters only)
U.S. Senate
SR-249 Russell Senate Office Building
Washington, D.C. 20510-2502

The Honorable Harold L. Volkmer
U.S. House of Representatives
2409 Rayburn House Office Building
Washington, D.C. 20515-2509

The Honorable James M. Talent
U.S. House of Representatives
1022 Longworth House Office Building
Washington, D.C. 20515-2502

The Honorable William L. Clay
U.S. House of Representatives
2306 Rayburn House Office Building
Washington, D.C. 20515-2501

The Honorable Richard A. Gephardt
1432 Longworth
House Office Building
Washington, D.C. 20515

Ms. Catherine Moore
Office Manager
U.S. Senator Christopher S. Bond
8000 Maryland Avenue
Suite 1050
St. Louis, Missouri 63105

Ms. Karla Roeber
District Administrator
U.S. Senator John Danforth
8000 Maryland Avenue
Suite 440
St. Louis, Missouri 63105

Mr. Rod Sippel
Administrative Assistant
U.S. Representative Gephardt
9959 Gravois
St. Louis, Missouri 63123

Ms. Pearlie Evans
District Assistant
U.S. Representative William L. Clay
6197 Delmar
St. Louis, Missouri 63112

Mr. Lee Viorel
District Administrator
U.S. Representative Harold L. Volkmer
370 Federal Building
Hannibal, MO 63401

Ms. Molly McCombs
District Director
U.S. Representative James M. Talent
555 No. New Ballas Road
Suite 315
St. Louis, MO 63141

Ms. Barbara Cooper
Community Affairs Director
U.S. Representative James M. Talent
820 S. Main Street
Suite 206
St. Charles, MO 63301

STATE AND LOCAL ELECTED OFFICIALS:

The Honorable Mel Carnahan, Governor
State of Missouri
216 State Capitol Building
P.O. Box 720
Jefferson City, MO 65102

The Honorable Fred Dyer
R-2nd District
Missouri State Senator
1025 Sherbrooke
St. Charles, Missouri 63303

The Honorable Steve Ehlmann
R-23rd District
Missouri State Senator
820 South Main
Suite 302
St. Charles, Missouri 63301

The Honorable Harriet Brown (January to mid May)
Rm 105J
House Post-Office
State Capitol Building
Jefferson City, MO 65101-6806

The Honorable Harriet Brown (mid May to December)
P.O. Box 840
Wentzville, MO 63385

The Honorable William Luetkenhaus
D-12th District
Missouri House of Representatives
742 Hancock Road
Wentzville, Missouri 63385

The Honorable Joseph Ortwerth
R-17th District
Missouri House of Representatives
4140 Old Mill Parkway
St. Peters, Missouri 63376

The Honorable Ted House
D-15th District
Missouri House of Representatives
3077 Winding River Drive
St. Charles, Missouri 63303

The Honorable Cindy Ostmann
R-14th District
Missouri House of Representatives
445 Knaust Road
St. Peters, Missouri 63376

The Honorable Rich Chrismer
R-16th District
Missouri House of Representatives
25 Barkwood Trails
St. Peters, Missouri 63376

The Honorable Charles Gross
R-18th District
3019 Westborough Court
St. Charles, Missouri 63301

The Honorable Eugene Schwendemann
County Executive
St. Charles County Courthouse
118 North Second Street
St. Charles, Missouri 63301

The Honorable Bob Fisher
County Council
St. Charles County Courthouse
118 North Second Street
St. Charles. Missouri 63301

The Honorable Shirley Sisco
County Council
St. Charles County Courthouse
118 North Second Street
St. Charles, Missouri 63301

The Honorable Linda A. Brown
County Council
St. Charles County Courthouse
118 North Second Street
St. Charles, Missouri 63301

The Honorable Harold Kohrs
County Council
St. Charles County Courthouse
118 North Second Street
St. Charles, Missouri 63301

The Honorable John C. Hanneke
County Council
St. Charles County Courthouse
118 North Second Street
St. Charles, Missouri 63301

The Honorable Thomas McGovern
County Council
St. Charles County Courthouse
118 North Second Stret
St. Charles, Missouri 63301

The Honorable Carl L. Bearden
County Council
St. Charles County Courthouse
118 North Second Street
St. Charles, Missouri 63301

Mr. Lee Brotherton
Administration Building, 9th Floor
41 South Central
Clayton, Missouri 63105

The Honorable Edward W. Hajek, Jr.
Mayor, City of Lake St. Louis
1000 Lake St. Louis Boulevard Suite 16
Lake St. Louis, Missouri 63367

The Honorable Ed Griesenauer
Mayor, City of O'Fallon
138 South Main Street
O'Fallon, Missouri 63366

The Honorable Grace Nichols
Mayor, City of St. Charles
St. Charles City Hall
200 North Second Street
St. Charles, Missouri 63301

The Honorable Freeman Bosley Jr.
Mayor, City of St. Louis
City Hall, Room 200
Market and Tucker Streets
St. Louis, Missouri 63103

The Honorable Thomas W. Brown
Mayor, City of St. Peters
Post Office Box 9
St. Peters, Missouri 63376

The Honorable Stephen Kochanski
Mayor, City of Cottleville
P.O. Box 387
Cottleville, Missouri 63338

The Honorable Anita Foelsch
Mayor, City of Weldon Spring
5499 Bourbeuse Common
St. Charles, Missouri 63304

Mr. William Schultejans
Chairman of the Board of Trustees
Town of Weldon Spring Heights
9 Weldon Spring Heights
St. Charles, Missouri 63304-5623

The Honorable Lee Barton
Mayor, City of Wentzville
Post Office Box 308
Wentzville, Missouri 63385

FEDERAL OFFICIALS:

Mr. William Rice
Acting Administrator
U.S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Mr. Robert Morby
Superfund Branch
U.S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Mr. Dan Wall (4 copies)
Superfund Branch
U.S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Ms. Denise Jordan-Izaguirre
Sr. Regional Representative
ATSDR c/o EPA
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Mr. Steve Iverson, Project Manager
Program and Project Management Division
U.S. Army Corps of Engineers
Kansas City District
601 East 12th Street
Kansas City, Missouri 64106
ATTN: CEMRK-ED-MD

Mr. Mike Green
Engineering Division
U.S. Army Corps of Engineers
Kansas City District
601 East 12th Street
Kansas City, Missouri 64106
ATTN: CEMRK-ED-GH

Mr. Karl J. Daubel
Environmental Coordinator
Weldon Spring Training Area
7301 Highway 94 South
St. Charles, Missouri 63304

STATE AND LOCAL OFFICIALS:

Mr. David A. Shorr
Director, Missouri Department of Natural Resources
Post Office Box 176
Jefferson City, Missouri 65102

Mr. Robert Geller (5 copies)
Missouri Department of Natural Resources
Post Office Box 176
Jefferson City, Missouri 65102

Mr. William Dieffenbach
Asst. Planning Division Chief
Missouri Department of Conservation
Post Office Box 180
Jefferson City, Missouri 65102-0180

Mr. Larry Erickson
Division of Environmental Quality
Missouri Department of Natural Resources
Post Office Box 176
Jefferson City, Missouri 65102

Mr. Roy Grimes, Manager
August A. Busch Memorial Wildlife Area
Route 2, Box 223
St. Charles, Missouri 63304

Mr. Gary Novinger
Fish and Wildlife Research Center
Missouri Department of Conservation
1110 College Avenue
Columbia, Missouri 65201

Mr. Lynn Bultman
Vice President
Missouri Cities Water Co.
1290 Motherhead Rd.
P.O. Box 390
Cottleville, Missouri 63338-0390

Mr. Roger Dunajcik
Environmental Sanitarian
St. Charles County Health Department
305 N. Kingshighway
St. Charles, Missouri 63301

Mr. Thomas Aaron
St. Charles County Water Department
1635 South Highway 94
Defiance, Missouri 63341

Mr. Terry Gloriod
Vice President for Production
St. Louis County Water Department
535 North New Ballas Road
St. Louis, Missouri 63141

Mr. Dave Visintainer
City of St. Louis Water Division
Chain of Rocks Plant
10450 Riverview Drive
St. Louis, Missouri 63137

Mr. Ken Hogan
City of St. Louis Water Division
Howard Bend Plant
14769 Olive
Chesterfield, Missouri 63017

DOE HEADQUARTERS:

Mr. Steve Wyatt
U.S. Department of Energy
Post Office Box 2001
Oak Ridge, Tennessee 37831-8052

Mr. James J. Fiore, Director
Office of Eastern Area Programs
U.S. Department of Energy
Division of Environmental Restoration
104 Trevion II Building
12800 Middlebrook Road
Germantown, Maryland 20874

Mr. Jim Wagoner, EM-41 (5 copies)
Decontamination & Decommissioning
Division
Eastern Area Programs Division
U.S. Department of Energy
19901 Germantown Road
Germantown, Maryland 20874

Mr. Kenneth Duvall, EH-232
Air, Water and Radiation Division
U.S. Department of Energy
1000 Independence Avenue
Washington, D.C. 20585-0002

Juliet Berling, EH-222
Environmental Protection Specialist
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, D.C. 20585

DOE-ORO:

Mr. Peter J. Gross, SE-31 (3 copies)
Director of Environmental Protection Division
Oak Ridge Field Office
U.S. Department of Energy
Post Office Box 2001
Oak Ridge, Tennessee 37831-8738

Mr. Wayne Hibbits SE-30
Deputy Assistant Manager for Environmental Safety and Quality
Oak Ridge Operations
U.S. Department of Energy
Post Office Box 2001
Oak Ridge, Tennessee 37831-8730

Mr. Grover Smithwick M2
Deputy Manager
Oak Ridge Field Office
U.S. Department of Energy
Post Office Box 2001
Oak Ridge, Tennessee 37831-8738

Mr. R.R. Nelson SE-30
Assistant Manager for Environmental Safety and Quality
Oak Ridge Field Office
U.S. Department of Energy
Post Office Box 2001
Oak Ridge, Tennessee 37831-8738

Mr. J.C. Hall EO-20
Assistant Manager for Enriching Operations
Oak Ridge Field Office
U.S. Department of Energy
Post Office Box 2001
Oak Ridge, Tennessee 37831-8738

ORAU:

Mr. J.D. Berger
Oak Ridge Associated Universities
230 Warehouse Road
Building 1916-T2
Oak Ridge, Tennessee 37830

MEDIA:

Mr. Jim Mueller
St. Charles Journal
340 North Main Street
St. Charles, Missouri 63301

Ms. Judith Vandewater
St. Charles Post
123 North Main Street
St. Charles, Missouri 63301

Mr. Tom Uhlenbrock
Environmental Reporter
St. Louis Post-Dispatch
900 North Tucker Boulevard
St. Louis, Missouri 63101

Mr. Evan Forrester
KMOV-TV, Channel 4
One Memorial Drive
St. Louis, Missouri 63102

Mr. William H. Allen
Science Writer
St. Louis Post Dispatch
900 N. Tucker Blvd.
St. Louis, Missouri 63101

LIBRARIES:

Kisker Road Branch
St. Charles City/County Library
1000 Kisker Road
St. Charles, Missouri 63303

Spencer Road Branch
St. Charles City/County Library
425 Spencer Road
St. Peters, Missouri 63376

Kathryn M. Linneman Branch
St. Charles City/County Library
2323 Elm Street
St. Charles, Missouri 63301

SCHOOLS:

Francis Howell School District
Consultant
Mr. Donald J. McQueen
Shannon & Wilson Inc.
11500 Olive Blvd. Suite 3276
St. Louis, Missouri 63141

Mr. Robert Shoewe, Principal
Francis Howell High School
7001 Highway 94 South
St. Charles, Missouri 63304

Dr. John Oldani
Superintendent
Francis Howell School District
7025 Highway 94 South
St. Charles, Missouri 63304

Mr. Dan Brown
Deputy Superintendent
Francis Howell School District
7025 Highway 94 South
St. Charles, Missouri 63304

OTHER:

Ms. Martha Gill
7 Weldon Spring Heights
St. Charles, Missouri 63304-5623

Ms. Margaret Culver
City of Weldon Spring
Board of Alderman
202 Wolfrum Road
St. Charles, Missouri 63304

Administrative Record (2 copies)
MK-Ferguson Company
7295 Highway 94 South
St. Charles, Missouri 63304

Ms. Meredith Hunter
258 Cedar Groves
St. Charles, Missouri 63303

Dr. Michael Garvey
208 Pitman Road
St. Charles, Missouri 63303

Ms. Bobbie Judge
812 Saratoga Heights Drive
St. Charles, Missouri 63304

Distribution (2 copies)
Office of Scientific and Technical Information
U.S. Department of Energy
Post Office Box 62
Oak Ridge, Tennessee 37830

Mr. Park Owen (2 copies)
Martin-Marietta Energy Systems, Inc.
K-25 Site
Post Office Box 2008
Building K-1210, MS-7256
Oak Ridge, Tennessee 37831-7256

Mr. Stanley M. Remington
Consulting Hydrologist
919 Broadmoor Lane
St. Charles, Missouri 63301

Mr. Robert M. Wester, President
R.M. Wester and Associates, Inc.
215 Indacom Drive
St. Peters, Missouri 63376

Ms. Kay Drey
515 West Point Avenue
University City, Missouri 63130

Bill Ferdinand
Quivra Mining Co.
6305 Waterford Boulevard
Suite 325
Oklahoma City, OK 73118

Mr. Mark Lusk
ASI
477 North Shoup Ave.
Suite 107
Idaho Falls, ID 83402

Dr. Margaret MacDonell (4 copies)
EID Division
Argonne National Laboratory
9700 South Cass Avenue, Building 900
Argonne, IL 60439

Ms. Jody Lally
Boston University School of Public Health
Environmental Health Dept.
Talbot 3C
80 East Concord
Boston, MA 02118

Ms. Alicia Taylor
FERMCO
P.O. Box 398704
MS-19
Cincinnati, Ohio 45030

SCCAHW:

Mr. Kenneth Gronewald
804 Birdie Hills Road
St. Peters, Missouri 63376

Mr. John Soucy, M.D.
SCCAHW
4 Weldon Spring Heights
St. Charles, Missouri 63304

Ms. Mary Halliday
3655 Highway D
Defiance, Missouri 63341

Mr. George Farhner
892 California Trail
St. Charles, Missouri 63304

Mr. Jerry Branbander
Columbia Field Office
U.S. Fish and Wildlife Service
608 E. Cherry Street
Room 207
Columbia, MO 65201

Mr. Conn Roden
111 S Meramec
2nd Floor
Clayton, MO 63105

Mr. Dale Schreiber
46 Broadview Dr.
St. Louis, MO 63105

Ms. Gwen Hobbs
9 Spencer Trail
St. Peters, MO 63376